VOLUME XXIX AUGUST, 1940 NUMBER 3

THE PHILIPPINE AGRICULTURIST

UNIVERSITY OF THE PHILIPPINES PUBLICATIONS: SERIES A

CONTENTS

Developmental Morphology of the Leaf of Maguey ----------- By *Tsui Kwok Hing* 185

A Study on the Nature of Weathering of Volcanic Tuffs under Los Baños Conditions -------------------- By *N. L. Galvez* 226

Studies on the Nutritive Value of the Elon-elon Rice Variety Grown in Different Parts of the Islands - By *José R. Velasco* 238

A Study of Jaragua Grass as a Forage Crop -------------------- By *Alejandro O. Obillo* 253

Observations on the Influence of Various Methods of Feeding Ducklings ----------------- By *Lorenzo M. Ancheta* 262

College and Alumni Notes ----------------------- 272

◆

Published by
THE COLLEGE OF AGRICULTURE
UNIVERSITY OF THE PHILIPPINES

COMMONWEALTH MYCOLOGICAL INSTITUTE
10 OCT 1961

IMPERIAL BUREAU OF PASTURES & FORAGE CROPS
LIBRARY
ABERYSTWYTH, GREAT BRITAIN.

18 FEB 1942

The Philippine Agriculturist

(University of the Philippines Publications: Series A)

Editor

L. B. UICHANCO, SC.D. .... *Dean, College of Agriculture*

Managing Editor

G. O. OCFEMIA, PH.D. .... *Associate Professor of Plant Pathology*

Copy Editor

RUTH MCCULLOUGH MACK, M.A. .... *Assistant Professor of English*

Advisory Board

N. B. MENDIOLA, PH.D. .... *Director of Research*

R. B. ESPINO, PH.D. .... *Head, Department of Agricultural Botany*

F. O. SANTOS, PH.D. .... *Head, Department of Agricultural Chemistry*

A. L. TEODORO, PH.D. .... *Head, Department of Agricultural Engineering*

VALENTE VILLEGAS, PH.D. .... *Head, Department of Animal Husbandry*

DIONISIO I. AQUINO, PH.D. .... *Acting Head, Department of Soils*

FRANCISCO M. SACAY, PH.D. .... *Acting Head, Department of Agricultural Education*

JOSÉ E. VELMONTE, B.S.C. .... *Acting Head, Department of Agricultural Economics*

LEON G. GONZALEZ, PH.D. .... *Acting Head, Department of Agronomy*

Business Manager

JOSÉ M. CAPINPIN, PH.D. .... *Assistant Professor of Agricultural Botany*

Authors of articles appearing in THE PHILIPPINE AGRICULTURIST are severally responsible for the opinions expressed therein.

THE PHILIPPINE AGRICULTURIST is published monthly, except in April and May, by the College of Agriculture, University of the Philippines, Los Baños, Laguna. The subscription price is ₱4.00 a year in the Philippines and $2.50 elsewhere; the price of single copies, 40 centavos in the Philippines and 25 cents elsewhere.

Business correspondence should be addressed to the Business Manager, THE PHILIPPINE AGRICULTURIST, Agricultural College, Laguna, Philippines. All remittances should be made payable to THE PHILIPPINE AGRICULTURIST.

Communications for the editor should be addressed to the Editor, THE PHILIPPINE AGRICULTURIST, Agricultural College, Laguna, Philippines.

Publications sent in exchange for THE PHILIPPINE AGRICULTURIST should be addressed: Library, College of Agriculture, Agricultural College, Laguna, Philippines.

Entered at the Post Office at Agricultural College, Laguna, Philippines, as second-class mail matter.

DEVELOPMENTAL MORPHOLOGY OF THE LEAF OF MAGUEY[1]

TSUI KWOK HING

WITH EIGHT PLATES

Maguey, *Agave cantala* Roxb., is noted for its valuable fibers. Its fresh leaves are utilized as feed for animals and in the manufacture of alcohol (De Candolle, 1919). Extensive literature on its cultivation and the extraction of its fibers is now available (Royle, 1855; Dodge, 1897; Edwards, 1906; Saleeby, 1913; Smith, 1929; Shepherd, 1932; Cruz, 1937). The developmental morphology of its leaves, however, seems to have escaped the attention of investigators. The fragmentary information on the anatomy of the leaf does not include its developmental anatomy which is concerned in the production of commercial fiber. Since a knowledge of foliar morphology is useful with plants yielding commercial fibers, this study should be of interest. In the present paper an attempt has been made to describe the development of the leaf and its tissues. Tests of the tensile strength of fibers obtained from the different leaves were also made.

Foster (1936) reported considerable literature on the histogenesis of various types of foliar structures and their development, but none is mentioned on *Agave cantala.* Aldaba (1923) noted crack-like fissures in the walls of the fiber cells of some species of *Agave* but failed to observe the same in *A. cantala.* Espino and Novero (1923) studied color-reaction, tensile strength, and ash content of maguey fiber as well as other fibers in the Philippines. Nutman (1937a) first attempted to classify the fibers of the leaves of this plant according to their anatomy. Gehlsen (1939) made a detailed study of the mature leaves of *A. rigida* (sisal).

MATERIALS AND METHODS

The leaves of maguey used in this study were taken from mature plants about five years old, growing in the College of Agriculture at Los Baños, Laguna. All the leaves from six plants were

---

[1] Thesis presented in March, 1940, in partial fulfillment of the requirements for the degree of Master of Science in Agricultural Botany, from the University of the Philippines. Experiment Station contribution No. 1366. Prepared in the Department of Agricultural Botany under the direction of Assistant Professor José B. Juliano.

THE PHILIPPINE AGRICULTURIST, VOL. XXIX, No. 3, AUGUST, 1940.

numbered and classified according to the angles they formed with the main axis. Those between 60° and the ground level, which usually form an angle of 90° with the main axis, belong to group 1, those between 30° and 60°, to group 2, and those between 0° and 30°, to group 3. All except the furled leaves of each group from the plants were numbered and cut close to the main axis. Each group of leaves was again divided into two lots. Lot 1 was retted in running water in Molawin Creek, whereas lot 2 was scraped with a porcelain plate on a wide, smooth board. The fibers from each leaf in each lot of the individual groups were separately washed, cleaned, and dried in a room. Their tensile strengths were then determined with a "Scott Tester" machine following the procedure described by Mathews (1924). Unless otherwise stated, the portion of the fiber used in the determination of tensile strength was that near its butt end. The weight of the sample used in the determination of the tensile strength was obtained with an analytical balance. The tensile strength expressed in kilogram-weight per gram sample of 25.5 centimeters long was then calculated.

For histological study, leaves at different stages of development were collected and pickled from October, 1937, to March, 1939. From each leaf sample specimens from the butt end, middle, and distal portion were taken and fixed in various fixatives. Craf's solution A and B (Randolph, 1935) proved to be the best. Materials from very old leaves required softening in 50 per cent hydrofluoric acid for twenty-four to thirty-six hours before being run through paraffin. The materials were treated in the usual manner, dehydrated in ethyl-butyl alcohol (Zirkle, 1930), and embedded in paraffin. The sections were then cut 10 to 15μ in thickness and stained in Heidenhain's iron-alum haematoxylin and Delafield's haematoxylin with a counter stain of orange G dissolved in clove oil (Chamberlain, 1932).

Free hand sections, made from leaves at various stages of development, were stained mostly in safranin light green and mounted in glycerine jelly. For the study of the fibro-vascular bundles, clearing with lactic acid was also tried by allowing the sections to remain in an electric oven at a temperature of 54°C.

RESULTS AND DISCUSSION

Mature leaf

Description. The leaf is linear-lanceolate, thick, fleshy, more or less glaucous on both surfaces, from two to three centimeters in the central portion and three to ten millimeters at its margins, and from one to two meters long and 7 to 13 centimeters wide. It is narrowed at both ends. Its apex has a spine, and its margins have spine-like teeths. In transverse section its basal portion is somewhat rounded, but at the middle it becomes thinner and wider, sloping gradually towards the margins.

The leaves are crowded on a short stem; those below are generally much longer than those near the growing point of the main axis (table 1). The leaves form various angles with the stem. The youngest ones surrounding the main axis are furled like a cylinder (Pl. 3, fig. 20*a-d;* Pl. 5, fig. 32 and 34). As the leaves grow, they unfold and spread out radially in all directions forming larger angles with the main axis. Frequently some over-mature leaves may form an angle of about 90° with the stem, and these almost touch the ground. In this paper, this angle serves as a basis for separating the leaves into groups when the tensile strength of their fibers is compared.

Anatomy. The epidermis of the leaf completely covers the blade. In surface section the lower epidermal cells (Pl. 1, fig. 1 and 4; Pl. 8, fig. 60) are nearly rectangular to hexagonal in shape, practically leaving no intercellular spaces between them. The continuity of the epidermal layer is broken at regular intervals by the presence of rectangular external air-chambers of the sunken stomata (Pl. 8, fig. 60). The walls of the epidermal cells are thin when young (Pl. 1, fig. 1), but as they mature, they deposit secondary wall materials, especially cutin. This thickening is much more pronounced in cells surrounding the outer air-chambers of the stomata. The deposition of secondary materials usually takes place only on the outer tangential walls of the epidermal cells and on half of the radial ones (Pl. 1, fig. 5 to 7). The upper epidermal cells are somewhat, uniform in size and shape (Pl. 1, fig. 2 and 3; Pl. 8, fig. 59). These may be hexagonal in outline. Their walls are thin when young and without any intercellular spaces between them. The thickening of the walls of the epidermal cells surrounding the external air-chambers to the stomata in this epidermal layer is much delayed and only becomes apparent at maturity of the blade.

On the outer surface of the epidermal layer is a rather thick coating of a granular waxy substance which is readily removed during cutting, fixing, and staining processes.

In transverse sections the lower epidermal cells are fairly uniform in shape but not in size. These are more or less rectangular, with their long axis at right angles to the surface of the leaf blade. Their outer tangential walls and half of their radial ones are heavily thickened and cutinized (Pl. 1, fig. 5 to 7), whereas their inner tangential walls are thin. The epidermal cells at the midportion of the blade (Pl. 1, fig. 6) and at the basal end (Pl. 1, fig. 7) are somewhat smaller than those towards the distal end of the blade (Pl. 1, fig. 5). The outer surface of the epidermal layer seems to be irregular in outline, and this waviness is more pronounced at the midportion of the blade (Pl. 1, fig. 6) than at any other region. The cuticular layer on the outer tangential epidermal wall is thickest near the basal end of the blade (Pl. 1, fig. 7).

The upper epidermis presents a structural differentiation similar to that in the lower epidermis. At the distal end of the blade, the epidermal cells are more elongated (Pl. 1, fig. 8) in transverse section than those at the midportion (Pl. 1 fig. 9), but the largest epidermal cells are at the basal end (Pl. 2, fig. 10). In general the cuticular layer covering the outer tangential walls of the epidermal cells is thicker on this region of the blade than on the lower epidermis (Pl. 1, fig. 5 to 7). The upper surface of the blade is somewhat even, although it may be wavy at the midportion of the blade (Pl. 1, fig. 9).

The stomata are sunken (Pl. 2, fig. 11). Each consists of two small subsidiary cells and two oblong guard cells. The outer tangential walls of the epidermal cells curve inward forming the external air-chamber. In a section, the external air chamber is shaped like the letter U with the guard cells at the bottom of the letter. The guard cells possess scanty chloroplasts. Underneath the stoma is an inner air-chamber which contains rhomboidal crystals of calcium oxalate. Although stomata are present on both surfaces of the blade, they are more abundant on the lower surface than on the upper. From the physico-anatomical viewpoint, these stomata are xerophytic in nature and are somewhat similar to those described by Eames and MacDaniels (1925).

The mesophyll consists of a ground parenchyma in which the vascular bundles are scattered. The parenchymatous cells may be ovoid, oblong-ovoid, or oblong with rounded corners. Their long axes may be at right angles to the epidermis leaving considerable intercellular spaces between. The mesophyll cells vary in size and shape in the different portions of the blade. The mesophyll cells tend to reduce in size towards the epidermal layers, whereas those centrally located are large and rather loosely connected.

At the basal end of the blade, the mesophyll cells are mostly rounded (Pl. 1, fig. 7; Pl. 2, fig. 10) and more or less compact, and the intercellular spaces are rather small. These features perhaps suggest that at this region, the mesophyll cells are still meristematic and are responsible for the elongation of the leaf. In general the last tissue to mature in the leaf blade is the basal region (Avery, 1933).

At the midportion of the blade, the mesophyll cells are usually large (Pl. 1, fig. 6 and 9). The peripheral mesophyll cells are somewhat ovate to oblong and fairly regular in size, but towards the center they become oblong and increase in size considerably. Mesophyll cells directly abutting the vascular bundles are very much smaller than the rest of the mesophyll cells (Pl. 2, fig. 13; Pl. 8, fig. 54-56) and tend to be oval or rounded.

At the distal end of the blade, the mesophyll parenchyma (Pl. 1, fig. 5 and 8) is almost like that at the basal end of the blade. The peripheral parenchyma cells are ovate to ovate-oblong and uniform in size, but those centrally located are somewhat rounded. Parenchymatous cells directly surrounding the vascular bundles are also rounded and much smaller than the rest of the mesophyll cells.

Large, hyaline, oblong cells containing raphide crystals of calcium oxalate (Pl. 2, fig. 12) may be scattered in the mesophyll. These raphide cells are believed by Haberlandt (1914) to be characteristic of the leaves of monocotyledons. The walls of these cells are uniformly thin. The crystals are perhaps responsible for the itchiness during the extraction of the fibers by hand-decortication. In addition to these raphide crystals, the writer also found rhomboid but larger crystals of calcium oxalate especially abundant around the inner air-chambers of the sunken stomata (Pl. 2, fig. 11). They were probably carried along during the preparation of the sections.

The mesophyll cells near the epidermal layers contain chloroplasts, but those centrally located are almost always colorless. In other words the chloroplasts are confined to the parenchymatous cells near the periphery of the blade. Inasmuch as the leaves may remain fresh and green in the laboratory for months, the colorless mesophyll cells may be considered as an aqueous tissue. Haberlandt (1914) states that this type of tissue serves as a reservoir from which water may be drawn by other living tissues, particularly the photosynthetic cells, in times of drought.

The vascular bundles run longitudinally throughout the length of the blade. Occasionally they may anastomose laterally forming what is known as the "commissural bundles". These bundles tend to be more numerous though smaller towards the epidermal layers and less numerous but larger towards the central portion of the blade. Smaller bundles can also be found among the large centrally located ones in the blade. Nutman (1937a) considers the distribution of fibers into: (*a*) the peripheral zone composed of one or more rather irregular rows of small fibers which are nearly circular in outline (Pl. 2, fig. 13, 14, 16), (*b*) the median line large fibers which are horseshoe-shaped (Pl. 3, fig. 17), and (*c*) the fibers lying between (*a*) and (*b*) (Pl. 8, fig. 57). Nutman calls "mechanical fibers" the small, somewhat circular fiber strands lying along the periphery throughout the parenchyma of the leaf blade. According to him these fibers are seldom associated with conducting tissues. He believes that they are of commercial importance because they seldom divide during extraction. The fibers from the vascular bundles at the median line of the blade and associated with the conducting tissues are the "ribbon fibers". They are crescent-shaped with the phloem of the bundles in the open side, and form the bulk of the fiber of commerce. The xylem bundle cap, "xylem fiber", forms a part of the composite bundle sheath at the median line of the blade. It invariably breaks and is lost during decortication by machine. It is of no commercial importance. Gehlsen (1939) corroborates these findings of Nutman (1937a).

Materials examined by the writer confirm observations by Nutman (1937a) and Gehlsen (1939) on *Agave sisalana* and *A. cantala*. Near the upper and lower epidermal layers, the vascular bundles are rather small, oblong to nearly ovoid, and somewhat poor in conducting elements. A vascular bundle (Pl. 2, fig. 13) possesses an extensive phloem bundle cap which may be connected with a poorly formed xylem cap. Both of these nearly enclose the poorly developed conducting elements which consist of a single protoxylem vessel and a few young phloem elements. In some cases the bundle consists entirely of fiber cells (Pl. 2, fig. 16) so that this may be considered purely of mechanical importance to the blade. In others the conducting elements are entirely surrounded or enclosed by the bundle caps (Pl. 3, fig. 18; Pl. 8, fig. 55). Aldaba (1923) states that zapupe, sisal, and maguey fibers are never devoid of conducting elements. The writer noted, however, that fiber strands without conducting elements are invariably present among the peripheral bundles of the leaf blade of maguey. This condition will classify the fiber strands of maguey with those of *Furcroea gigantea*[2] (Mauritius hemp) and *Agave furcroydes* Lemaeir (Henequen).

Occasionally there are a few peripheral bundles which may show well-differentiated phloem and xylem regions, but the bundle caps are still poorly developed (Pl. 2, fig. 15). In some cases these peripheral bundles may have only their phloem caps well differentiated with no sign of development of the xylem bundle cap (Pl. 2, fig. 14; Pl. 8, fig. 54). These bundles are not only confined to the periphery of the leaf blade, but they are also scattered at the median line of the blade as reported by Nutman (1937a).

In cross section, the median large bundles are ovate to elliptic, with well-developed phloem and xylem caps. They usually have their long diameters at right angles to the epidermal layers. The bundle caps opposite the phloem are much more developed than those opposite the xylem (Pl. 3, fig. 17). They are crescent-shaped and consist of homogeneous sclerenchymatous cells with comparatively small lumina. Separating the two bundle caps at their extremities are one to two layers of parenchyma. The xylem is composed of a varying quantity of vessels with spiral thickenings (Pl. 7, fig. 53) and is regular in shape and size. Between the xylem vessels and the xylem cap are large, irregularly shaped parenchyma with wavy walls apparently shrunken by the killing and staining processes. The phloem is composed of numerous sieve tubes and companion cells. From one to two layers of large phloem parenchyma cells lie between the xylem vessels; much larger ones are between the phloem and the phloem cap.

The bundles found between the large median bundles and the smaller peripheral ones are very similar to the median bundles (Pl. 8, fig. 57). These are, much smaller, however, but their component parts are nearly identical with the median bundles. Their orientation is somewhat variable; some may have their bundle caps directed at right angles to the epidermis, and others, parallel to the epidermal layers. These bundles are classified by Nutman (1937a) as the third type found in his material. Together with the median bundles these are extracted for commercial fiber production.

---

[2] According to Willis (1931) the genus should be *Furcraea* Vent.

The median bundles as well as those lying below and above the peripheral small bundles have a mean larger diameter of the cross sectional area of 356.3 ± 3.6μ at the distal end, 404.4 ± 4.0μ at the midportion, and 413.2 ± 10.8μ at the basal end of the blade. In breadth they are fairly uniform. On the average from 1100 to 1500 bundles are found at the basal end and from 886 to 1050 bundles at the midportion of the blade. Towards the distal end the vascular bundles decrease in number and may vary from 158 to about two hundred. The vascular bundles decrease about eight times from the base to the apical regions of the leaf blade. These measurements included 380 bundles from group 2 leaves. Also the vascular bundles tend to be larger in transverse section at the butt end and correspondingly smaller at the distal end. Aldaba (1923) found that the large fiber strands in maguey may vary in gross diameter from 14.7μ to 25.2μ (average 17.8μ). The diameter of the lumina of the individual fiber cells may vary from 1.2μ to 8.4μ (average 5.0μ), whereas the thickness of the walls may vary from 4.9μ to 8.0μ (average 6.5μ). The length of the fiber cells may vary from 1,656.5μ to 5,679.8μ with an average of 3,015.7μ. The peripheral small fiber strands may range in width from 10.4μ to 16.5μ (average 13.6μ) in gross diameter, whereas the lumina of the fiber cells varies from 1.1μ to 4.2μ (average 3.2μ). The thickness of the fiber cell wall varies from 4.3μ to 6.3μ (average 5.3μ) and the length of the individual fiber cell from 1,290.9 to 3,810μ, with an average of 2,443.4μ.

Terminal and marginal spines

Each leaf of maguey has a well-developed terminal spine and numerous small spines along the margins. The terminal spine differentiates quite early in the development of the leaf and much earlier than the marginal. When the furled leaf blade is only about five centimeters long, it already has a well-differentiated terminal spine (Pl. 3, fig. 20*a*), while the marginal spines are still in a rudimentary stage or wanting. The apical spine is rather hard and pointed. When mature, both the terminal and the marginal spines are dark purplish brown.

When the leaf is young, the terminal spine is small and light brown. At maturity of the leaf this spine becomes dark brown and rounded in transverse section. The epidermal layer is covered with a thick cuticle (Pl. 4, fig. 21). Scattered on the epidermis are stomata, identical in structure to those of the mature leaf blade. The epidermis consists of rectangular cells in transverse section; at times they may be flattened. Below this are two to five layers of chlorophyllous parenchymatous cells. These disappear near the tip of the spine and are replaced entirely by strands of sclerenchyma. Scattered in the sclerenchymatous cells of the spine are poorly developed vascular bundles (Pl. 3, fig. 19). The walls of these never become thickened. The bundles consist mostly of parenchyma with very few well-defined water conducting elements. The bundles thin out towards the tip of the spine. The individual cells of the ground tissue are more or less hexagonal in transverse section. In longitudinal section they are greatly elongated and have very much lignified and thickened walls traversed by numerous pits (Pl. 4, fig. 22; Pl. 8, fig. 58). The ends of the cells of the ground tissue are obliquely tapering or squarely cut. The sclerenchymatous cells may at various points abut directly upon the epidermal layer, breaking the continuity of the chlorophyllous tissue of the spine.

The fiber

In the Philippines, the fiber of maguey is usually extracted by retting in salt or fresh water (Aldaba, 1923; Anonymous, 1925), but in other countries, such as South Africa, machine decortication is used (Nutman, 1937a). In this study the fibers were extracted by hand with a porcelain plate and by retting in fresh running water. Hand-scraped fibers were coarse and white to creamy white. The individual fibers were large, perhaps because they were not split during the extraction process. The mucilaginous or gummy substances (Smith, 1929) in the leaves may not have been thoroughly removed during the brief period of washing the hand-scraped fiber and may perhaps be responsible for the tendency of the fibers to remain intact. The retted fibers were more or less yellowish and finer in texture.

Anatomy. Microscopic sections of hand-scraped fibers show that xylem elements (Pl. 4, fig. 27) may adhere to the xylem cap. Sometimes crushed phloem and parenchyma cells may also adhere to the phloem caps. The parenchyma are usually destroyed during the extraction and drying of the fibers, whereas the bundle caps are much better preserved owing to the lignification and thickness of the walls of their cells. The majority of the hand-scraped fibers are derived from the central vascular bundles, especially the median line (Pl. 4, fig. 27). The bundles from the peripheral zone of the blade are almost entirely destroyed or thrown away during the process of extraction. Only a few of them find their way to the extracted fibers (Pl. 4, fig. 28).

The retted fibers are almost always derived from tne phloem bundle caps. As these are invariably broken into small segments, (Pl. 4, fig. 23 to 25), the extracted fibers are finer in texture. The xylem elements, especially those derived from the periphery of the blade, may remain attached to the bundle cap (Pl. 4, fig. 26, 29). A great portion of the peripheral bundles is extracted by retting.

The fiber cells

Macerated fibers show that the fiber cells of maguey are libriform with sharply tapering or pointed ends (Pl. 5, fig. 30*b*, *c*, *d*, *e*, *f*). Aldaba (1923) found that the majority of the cell ends are not so tapering as in zapupe and more frequently they are rounded. He found also that sisal has fiber cells with sharper ends than maguey. The walls of the fiber cells are uniform in thickness, and the lumina are quite large (Pl. 5, fig. 30*a*). The writer noted crack-like fissures on the walls of the individual fiber cells, but Aldaba (1923) did not. The apices of the fiber cells may taper gradually (Pl. 5, fig. 30*c*), but some of them occasionally taper abruptly near their apices (Pl. 5, fig. 30*d*, *e*) or have curved ends (Pl. 5, fig. 30*f*). The length of fiber cells is many times their diameter. Aldaba (1923) states that the lengths of the fiber cells from the large central bundles ranged from 1,656.5 to 5,679.8μ (average, 3,015.7μ), whereas those from the peripheral region of the blade range from 1,290.9 to 3,810.0μ (average, 2,443.4μ).

The fiber cells from the peripheral bundles are finer and have thinner walls than those from the centrally located fibers. Aldaba (1923) found that the average diameter of the lumina of fiber cells from the peripheral bundles was 3.2μ, whereas that from the centrally located bundles was 5.0μ. The thickness of the walls was 5.3μ and 6.5μ, respectively, for the two types of cells mentioned above.

Tensile strength

In studying the frequency-distribution of the tensile strengths of the fibers from each leaf, Nutman (1937b) found that there is a "general tendency for the higher-strength classes to increase in frequency at the expense of the low-strength classes as the leaves towards the bud are approached." He attributed the increase in tensile strength to an increase in the number of strong fibers. He also found that the fineness of the fibers decreases slightly with the age of the plant, except the earliest 'sand-leaves', which have a relatively coarse fiber.

Guiang[3] found that with the exception of a few of the oldest leaves of a maguey plant and of other species of *Agave* the fibers from the different leaves are about the same in tensile strength. Irrespective of the plant, the fiber from the youngest visible leaf was the finest, and as the leaf advanced in age, the fiber became relatively coarse.

Hand-scraped fibers. Tensile strength determinations of hand-scraped fibers from the different leaves are shown in table 2. Fibers obtained from group 1 leaves gave a mean tensile strength of 117.834 ± 2.025 kilograms per gram sample (25.5 centimeters long); those from group 2, 138.058 ± 1.6658 kilograms, and those from group 3, 132.626 ± 1.9019 kilograms. The fibers from group 2 leaves gave the highest tensile strength. The differences between the mean tensile strength of fibers obtained from group 1 leaves and those from groups 2 and 3 are significant. The differences between the tensile strengths of the leaves from group 2 and group 3 are insignificant (table 3). The fibers from groups 2 and 3 are nearly identical in tensile strength. A much stronger fiber, however, can be obtained from group 2 leaves if the fibers are extracted by the scraping method. The results obtained by the writer do not quite agree with those of Guiang. The lowest coefficient of variation was obtained from group 2 leaves (29.987 ± 0.9265 per cent), and the highest, from group 1 (34.182 ± 1.3487 per cent).

In order to ascertain what portion of the hand-scraped fiber gives the highest tensile strength, the fibers taken at random from groups 1, 2, and 3 leaves were cut into two at the middle. The tensile strength of the distal and basal segments were determined. The results showed that the mean tensile strength of the distal portion of the fibers from the three groups was 62.379 ± 1.2953 kilograms per gram sample. Compared with the mean tensile strength of the samples from the basal end of the fibers, the difference in all cases was highly significant in favor of the basal portion. The distal portions of the fibers were much weaker than their corresponding butt end as shown by Nutman (1937b) and Gehlsen (1939). Nutman (1937b) states that the position of the maximum strength of the fibers lies approximately one-third the distance from their butt ends, and the strength falls off uniformly on each side of this point.

---

[3] GUIANG, A. C. Comparative study of the fibers of different species of *Agave* and Mauritius hemp grown in Los Baños. (Thesis presented for graduation from the College of Agriculture, University of the Philippines for the degree of Bachelor of Agriculture. 1925. Unpublished.)

An anatomical study of the cross sections of the hand-scraped fibers clearly indicates that the portion near the butt ends of the fibers is much larger in diameter and, therefore, coarser than the corresponding portion near the distal ends. This difference in diameter of the fibers is perhaps largely responsible for the higher tensile strength of the portion of the fiber near the butt ends than near the tip.

Retted fibers. The tensile strength of the retted fibers from the different groups of leaves was also determined (table 2). The mean tensile strength of those from group 1 leaves was 77.051 ± 0.6407 kilograms per gram sample, from group 2, 78.44 ± 1.2227 kilograms, and from group 3, 82.30 ± 0.9500 kilograms. Thus the fibers from group 2 leaves are stronger than those from group 1, although the difference was insignificant (table 3). Fibers from group 3 leaves are significantly stronger than those from group 1, and those from group 3 are insignificantly stronger than those from group 2. The fibers from group 3 are the strongest. When the fibers are extracted by scraping, the strongest are obtained from group 2 leaves, but if retted in running water, the strongest are from group 3. No explanation can be given for this discrepancy.

Hand-scraped vs. retted fibers. In all cases the retted fibers exhibit a very much lower mean tensile strength than the scraped (table 2). Regardless of the position of leaves where the fibers were extracted, the differences in mean tensile strength of the two types of fibers are all significant. Aldaba (1923) mentions that the retted maguey fibers were weak and discolored.

Histological studies show that the hand-scraped fibers are composed of a very large number of fiber cells (Pl. 4, fig. 27, 28); the pressure exerted during scraping was perhaps not sufficient to break the bundle caps apart. Although present in the extracted fiber, the xylem bundle cap does not seem to contribute much to the mechanical strength of the fiber because it is poorly developed. Nutman (1937a) believes that in machine decortication the xylem bundle caps are usually removed. In retted fibers a splitting of the phloem bundle caps results in the extraction of smaller and finer strands (Pl. 4, fig. 23-25). This is perhaps one of the reasons for the retted fibers being finer and much weaker than the hand-scraped.

The tensile strengths of fibers obtained from different regions of a leaf blade were also studied. Results obtained by the writer indicate that the peripheral fibers when extracted by the scraping method (Pl. 4, fig. 28) have a very much lower tensile strength than those at the median portion of the blade (Pl. 4, fig. 27) and those lying between the peripheral and median fibers (Pl. 8, fig. 57). The mean tensile strength of the peripheral fibers was 122.595 ± 0.0037 kilograms per gram sample, whereas that of the median line bundles and of those lying below and above the peripheral bundles near the epidermal layers was 136.625 ± 1.8821 kilograms. The difference between these two means was significant (14.130 ± 2.74 kilograms per gram sample). Measurements given by Aldaba (1923) of the peripheral fiber cells and those lying below and above them reveal that the former have a larger gross diameter, smaller lumina, and thicker walls.

Development

The leaf primordium. The leaf primordium arises at the growing point of the stem in spiral succession (Pl. 5, fig. 31). It is a lunar-shaped hump of cells in transverse section (Pl. 5, fig. 32) similar to that reported by Skutch (1930) on banana. The leaf primordium consists of only two types of cells, namely, the protoderm and the ground meristem. As the cells in the ground meristem increase by both periclinal and anticlinal divisions, and the whole leaf primordium elongates, it emerges as a lateral protuberance from the growing point. Simultaneously more cells are added to the protodermal layer by anticlinal division. Increase in length, however, in this primordium is much faster than in breadth while it emerges upward from the growing point parallel to the main axis. As the young leaf further elongates upward, it appears furled (Pl. 3, fig. 20) owing to the much faster growth of the outer protodermal layer. Schüepp (1926) called this "foliar folding" of the young leaf primordia. The growth or expansion of the protodermal layer seems to be closely correlated with the peculiar folding of the young leaf. Only anticlinal division takes place in the protodermal layer (Pl. 5, fig. 35, 36, 37). Owing to the unequal rate in the anticlinal divisions and subsequent growth of the cells in the two surfaces of the very young leaf, the lower epidermis grows much faster than the upper. Thus, the two margins tend to curve inward towards the main axis (Pl. 5, fig. 32 and 34). At first the young leaves assume a vertical position, but as they mature, they gradually diverge from the main axis and unfurl their lamina. The furled young leaves are arranged in such a way that the younger leaf is almost completely enclosed by the next older one (Pl. 5, fig. 32 and 34). Incidentally, protection to the growing point is afforded by such a folding of the margins of the leaf primordia throughout.

The youngest rudimentary leaf examined by the writer consisted of a mass of meristematic, homogenous, isodiametric cells covered by a distinct protodermal layer. Vascular bundle strands were at first wanting in the ground meristem. The first provascular bundle strand to differentiate in the young leaf was found at the central portion of the blade (Pl. 5, fig. 32*b* and 33). Maguey and many other amaryllidaceous plants do not possess any distinct midrib in their blade and this provascular bundle is perhaps homologous to the midrib of the dicotyledonous leaf blade. The other median provascular bundles of the leaf then proceed to differentiate laterally towards the margins. The vascular bundles lying between the peripheral ones towards the lower epidermis and the median line bundles appear simultaneously (Pl. 5, fig. 34). Those lying toward the upper epidermis are formed later. The peripheral bundles appear last; those near the lower epidermis appear first, and those near the upper epidermis next.

The growth in thickness of the blade is accomplished by anticlinal and periclinal divisions of the mesophyll cells (Pl. 5, fig. 35 and 36). The initial mesophyll cells at the margins usually divide anticlinally (Pl. 5, fig. 36) in order that their inner daughter cell (Pl. 5, fig. 37a^1) may divide periclinally so as to give rise to two initial mesophyll layers. The outer daughter cell (Pl. 5, fig. 37a^2) from the first division of the initial cell continues to divide anticlinally and in this way increases the breadth of the blade. In some instances the writer observed that the growth of the protoderm is so rapid that the initial mesophyll is left behind (Pl. 5, fig. 35). No early differentiation of the mesophyll cells takes place in this species because the daughter cells of the initial mesophyll divide in all planes in order to increase considerably the breadth of the blade.

Vascular bundles. The development of the median line provascular strands and of those lying between them and the peripheral ones seem to be identical. The initial development of the first vascular strand in the young leaf has not been traced by the writer, but the subsequent bundle development thereafter appears to arise from a single cell (Pl. 6, fig. 38) of the mesophyll. This cell divides either horizontally or vertically (Pl. 6, fig. 39-40). Subsequent rapid cell divisions occur among these daughter cells, and a group of isodiametric small cells with dense protoplasmic contents differentiates and becomes the forerunner of the bundle (Pl. 6, fig. 41-42). In plate 6, figure 43, is shown further cell divisions taking place in the undifferentiated provascular strands. In the young vascular bundle the first tissue to mature is the xylem (Pl. 6, fig. 44), which consists of spiral vessels (Pl. 7, fig. 53). The cells opposite the differentiating xylem vessels towards the phloem region continue to divide; those directly abutting upon them generally stop dividing early and usually enlarge. The cells on the other side of the vessels increase in number (Pl. 6, fig. 46) and become the sclerenchymatous bundle cap as the bundle matures (Pl. 3, fig. 17).

At the region of the vascular strand opposite the differentiating xylem, the cells rapidly divide (Pl. 6, fig. 44-45) to form the phloem region; those lying at the middle later begin to enlarge (Pl. 6, fig. 45; Pl. 8, fig. 56) and completely divide this phloem region into two distinct groups of isodiametric cells (Pl. 7, fig. 47). The cells at the periphery of the bundle develop into the bundle cap at the phloem pole, whereas the inner group becomes the phloem proper (Pl. 3, fig. 17). The gap between the xylem and the phloem becomes discernible long before the lignification and thickening of the walls of the bundle caps. This gap develops by the centripetal enlargement of the bundle cells (Pl. 6, fig. 45; Pl. 7, fig. 47).

The development of the peripheral bundle bears a very close resemblance to the development of the median bundle. When the rudimentary leaf has completed the differentiation of its median bundles, the peripheral ones then appear. The provascular strand at the periphery develops from a single cell (Pl. 7, fig. 48) and usually appears at the middle portion of the blade, but differentiation proceeds towards the margins. The daughter cells of the initial bundle proceed to divide on all planes (Pl. 7, fig. 49), and a mass of small rectangular to polygonal cells are produced (Pl. 7, fig. 50). The xylem cells increase in number as the bundle matures (Pl. 7, fig. 51-52). Those bundle cells opposite the xylem may continue to divide further as the bundle develops. Thickening and lignification of the walls of the bundle cap cells opposite the xylem (Pl. 2, fig. 14) then follow, leaving only a few cells to form the phloem. In the majority of cases, lignification may proceed entirely around the xylem (Pl. 2, fig. 13). But in some cases, lignification may involve the whole fiber strand (Pl. 2, fig. 16) with no sign whatever of xylem and phloem differentiations. In rare cases lignification may not take place (Pl. 2, fig. 15); hence, only the xylem vessels become lignified.

SUMMARY AND CONCLUSIONS

A detailed study of the structure and development of the leaf of *Agave cantala* Roxb. and its tissue is presented. A determination of the tensile strength of the fibers from its leaves was made.

The leaf of maguey is highly adapted to a xerophytic condition because of a thick layer of cuticle, the waxy coating on both the lower and upper epidermis, the water storage mesophyll cells, and the sunken stomata.

The leaf primordium arises from a group of cells cut off at the growing point of the main axis. The young leaf primordium starts with a pronounced protodermal layer enclosing a homogenous ground tissue. The ground tissue increases in bulk by both anticlinal and periclinal divisions of the cells, whereas the protodermal layer, by the formation of anticlinal walls only. The growth in breadth of the young blade is brought about by subsequent or repeated divisions of an initial cell located at the margin of the mesophyll.

The leaf blade possesses three types of vascular bundles, namely, the median line, the peripheral, and those situated in between these two zones. These bundles are characterized by significant differences in the order of their development, arrangement, and relative size and number of their cells.

The vascular bundles differentiate from a single cell initial in the ground tissue, and periclinal and anticlinal cell divisions follow without definite sequence. Elongation follows immediately after the cell division; thus the provascular strand increases its diameter and length simultaneously. The medium bundles appear very much earlier than the other types during the development of the leaf primordium, and the peripheral bundles differentiate last among the three types of vascular bundles found in the blade.

The differentiation of the tissue in the bundle follows more or less a regular sequence. The xylem vessels differentiate first, and the phloem cells later. The bundles run parallel to the main axis of the leaf blade, but occasionally they may anastomose.

The number of the vascular bundles correspondingly increase with the age of the leaf blade. They are most abundant at the basal portion of the leaf and gradually decrease towards its distal end.

Determination of the tensile strength of fibers revealed that the hand-scraped ones from leaves forming angles with the main axis between 30° and 60° were the strongest, although no significant differences were found between these leaves and those approaching the tip of the main axis. In the retted fibers, however, the leaves borne at an angle of from 0° to 30° gave the highest tensile strength, although the difference between these and those directly below (group 2) was insignificant.

The retted fibers from any group of leaves were significantly weaker than the hand-scraped. The basal portions of the hand-scraped fibers were significantly stronger than their corresponding distal portions. Fibers from the median line bundles as well as those lying between them and the peripheral gave a higher tensile strength than the fibers from the latter.

The hand-scraped fibers are composed mainly of the median line bundles with phloem and bundle caps intact. The retted fibers, however, are composed mostly of smaller broken bundle caps. The retted fibers also include numerous peripheral bundles, which are weaker than the median bundles.

LITERATURE CITED

ALDABA, V. C. 1923. The fiber elements of some fiber-Agaves and Mauritius hemp. Philippine Agric. Rev. **16**: 120–129. *Pl. 4–8.*

ANONYMOUS. 1925. Preparation of maguey and sisal by retting. P.I. Bur. Agric. Cir. 99: 1-2.

AVERY, G. S., Jr. 1933. Structure and development of the tobacco leaf. Amer. Jour. Bot. **20**: 565–592. *Fig. 1–42.*

CHAMBERLAIN, C. J. 1932. Methods in plant histology. 5th. ed. xiv + 416 p., 140 fig. Chicago: University of Chicago Press.

CRUZ, E. E. 1937. A study of different species of Agave. Philippine Jour. Agric. **8**: 1–6.

DE CANDOLLE, A. 1919. Origin of cultivated plants. vii + 468 p. New York: D. Appleton and Company.

DODGE, C. R. 1897. A descriptive catalogue of useful fiber plants of the world. U.S. Dept. Agric., Fiber Investigation Div. Rept. 9: 1-361. *Pl. 1-12; fig. 1-103.*

EAMES, A. J., AND L. H. MACDANIELS. 1925. An introduction to plant anatomy. xiv + 364 p., 146 fig. New York: McGraw-Hill Book Company, Inc.

EDWARDS, H. T. 1906. The cultivation of maguey in the Philippine Islands. P.I. Bur. Agric. Farmers' Bull. **13**: 1–25. *Pl. 1–7.*

ESPINO, R. B., AND T. NOVERO. 1923. Mauritius hemp (*Furcroea gigantea*), with reference to its inferiority to abacá, maguey, and sisal. Philippine Agric. Rev. **16**: 108–119. *Pl. 1–3; fig. 3.*

FOSTER, A. S. 1936. Leaf differentiation in angiosperms. Bot. Rev. **2**: 349–372. *Fig. 1-10.*

GEHLSEN, C. A. 1939. Beiträge zur Anatomie der Blattfaserpflanzen. Der Tropenpflanzer **42**: 93–104. *Fig. 1–16.*

HABERLANDT, G. 1914. Physiological plant anatomy. xv + 777 p., 291 fig. *Translated by* M. DRUMOND. London: Macmillan Company.

MATHEWS, J. M. 1924. Textile fibers. xviii + 1053 p., 411 fig. London: John Wiley and Sons, Inc.

NUTMAN, F. J. 1937a. Agave fibers. I. Morphology, histology, length, and fineness; grading problems. Empire Jour. Exper. Agric. **5**: 73–92. *Pl. 2–4.*

NUTMAN, F. J. 1937b. Agave fibers. II. Mechanical qualities. Empire Jour. Bot. Agric. **5**: 93–111. *Fig. 1–7.*

RANDOLPH, L. F. 1935. A new fixing fluid and a revised schedule for the paraffin method in plant cytology. Stain Tech. **10** (3): 95–96.

ROYLE, J. F. 1855. The fibrous plants of India. xiv + 403 p., 6 fig. London: Smith Elder & Co.

SALEEBY, M. M. 1913. Maguey (*A. cantala*) and sisal culture. Philippine Agric. Rev. **6**: 183–188. *Pl. 10–13.*

SCHÜEPP, O. 1926. Meristeme. v + 114 p. 42 fig. Berlin: Verlag von Gebrüder Borntraeger.

SHEPHERD, E. T. S. 1932. Report on the Java fiber industry (*Agave sisalana, A. cantala*). Bull. Imp. Inst. (Great Britain) **30**: 444–450. *Cited in* Biol. Abst. **9** (3): 636. 1933.

SKUTCH, A. F. 1930. On the development and morphology of the banana (*Musa sapientum* L.) Amer. Jour. Bot. **17** (4): 252–275. *Fig. 1–19.*

SMITH, H. H. 1929. Sisal production and preparation. xxvii + 384 p., 12 pl., 21 fig. London: John Bale Sons and Danielsson, Ltd.

WILLIS, J. C. 1931. A dictionary of flowering plants. iv + 752 p. Cambridge: University Press.

ZIRKLE, C. 1930. The use of n-butyl alcohol in dehydrating woody tissue for paraffin embedding. Science **71**: 103–104.

EXPLANATION OF PLATES

PLATE 1

Fig. 1. Surface section of the lower epidermis of a young leaf showing external air-chambers (*eac*). × 112.

Fig. 2. Surface section of the upper epidermis of a mature leaf; (*eac*) external air-chamber. × 112.

Fig. 3. Surface section of the upper epidermis of a young leaf. × 112.

Fig. 4. Surface section of the lower epidermis of a mature leaf; (*eac*) external air-chamber. × 112.

Fig. 5. Portion of a cross section of the distal portion of a mature leaf blade; (*co*) calcium oxalate crystals; (*cu*) cuticular layer; (*lep*) lower epidermis; (*m*) mesophyll. × 112.

Fig. 6. Portion of a transverse section of the mature leaf blade at midportion; (*co*) calcium oxalate crystals; (*cu*) cuticular layer; (*lep*) lower epidermis; (*m*) mesophyll. × 112.

Fig. 7. Portion of a cross section of the blade at the basal end; (*co*) calcium oxalate crystals; (*cu*) cuticular layer; (*lep*) lower epidermis; (*m*) mesophyll. × 112.

Fig. 8. Portion of a transverse section of the mature blade taken at its distal portion; (*co*) calcium oxalate crystals; (*cu*) cuticular layer; (*iac*) inner air-chamber; (*m*) mesophyll; (*uep*) upper epidermis. × 112.

Fig. 9. Portion of a transverse section at the mid-portion of the mature leaf blade; (*co*) calcium oxalate crystals; (*cu*) cuticular layer; (*iac*) inner air-chamber; (*m*) mesophyll; (*uep*) upper epidermis. × 112.

PLATE 2

Fig. 10. Portion of a transverse section of the mature leaf blade at its basal end; (*co*) calcium oxalate crystals; (*cu*) cuticular layer; (*iac*) inner air-chamber; (*m*) mesophyll; (*uep*) upper epidermis. × 112.

Fig. 11. Transverse section of the mature blade through a stoma; (*chl*) chloroplasts; (*eac*) external air-chamber; (*iac*) inner air-chamber; (*lep*) lower epidermis; (*m*) mesophyll; (*sgc*) subsidiary guard cell. × 490.

Fig. 12. Raphide cell showing the raphides of calcium oxalate. × 99.

Fig. 13. Transverse section of a peripheral bundle from a mature leaf; (*m*) mesophyll cells; (*pbc*) phloem bundle cap; (*ph*) phloem region; (*xbc*) xylem bundle cap; (xy) xylem vessel. × 228.

Fig. 14. Another type of peripheral bundle with only phloem bundle cap well-developed; taken near the upper epidermis at the midportion of the blade; (*m*) mesophyll cell; (*xy*) xylem. × 228.

Fig. 15. A peripheral bundle devoid of sclerenchymatous caps situated near the upper epidermis of the leaf blade; (*co*) calcium oxalate; (*m*) mesophyll; (*ph*) phloem; (*xy*) xylem. × 228.

Fig. 16. A peripheral bundle devoid of conducting elements found at the margin of the midportion of the blade towards the lower epidermis. × 228.

PLATE 3

Fig. 17. Transverse section of a median line bundle taken at the midportion of the mature blade; (*pbc*) phloem bundle cap; (*ph*) phloem; (*xbc*) xylem bundle cap; (*xy*) xylem vessels. × 228.

Fig. 18. A peripheral bundle towards the lower epidermis at the distal portion of the blade; (*pbc*) phloem bundle cap; (*ph*) phloem; (*xbc*) xylem bundle cap; (*xy*) xyelm vessel. × 228.

Fig. 19. Portion of a transverse section of the mature terminal spine of the blade showing the ground sclerenchyma with a vascular bundle; (*ph*) phloem; (*xy*) xylem vessel. × 228.

Fig. 20. Young leaves; *a.* folded leaf with well developed terminal spine (blackened); *b.* a smaller leaf with rudimentary terminal spine; *c.* a still smaller leaf with beginnings of the terminal spine; *d.* rudimentary leaf devoid of terminal spine. × 1.

PLATE 4

Fig. 21. Portion of a transverse section of the mature terminal spine; (*cu*) cuticular layer; (*chl*) chloroplast; (*ep*) epidermis; (*scl*) sclerenchymatous ground tissue. × 228.

Fig. 22. Longisection of sclerenchyma found in the terminal spine. × 228.

Fig. 23. Transverse section of retted fibers. × 228.

Fig. 24-25. Transverse sections of retted fibers that are broken. × 228.

Fig. 26. Section of a peripheral retted fiber showing presence of xylem elements; (*xy*) xylem vessels. × 228.

Fig. 27. Transverse section of a hand-scraped median fiber showing the phloem bundle cap (*pbc*) together with (*xy*) xylem vessels; (*xbc*) xylem bundle cap. × 228.

Fig. 28. Transverse section of hand-scraped peripheral fiber with xylem vessels present; (*pbc*) phloem bundle cap. × 228.

Fig. 29. Transverse section of the retted peripheral bundle; (*xy*) xylem. × 228.

PLATE 5

Fig. 30a. The macerated fiber cell showing the lumen (*lu*); (*p*) crack-like fissures on the walls. × 490. *b-f.* Portions of fiber cells showing their apices. × 228.

Fig. 31. Median longisection of the growing point showing the leaf primordia. × 23.

Fig. 32. Diagram of a cross section of the young leaves; shaded areas are vascular bundles. × 56.

Fig. 33. Transverse section of the young leaf taken from fig. 32*b*, showing the first provascular strand (*prbs*); (*lep*) lower epidermis; (*uep*) upper epidermis. × 490.

Fig. 34. Diagram of a transverse section of the young leaf showing the peripheral bundle (*perb*) and those lying between the median and pheripheral ones; (*lep*) lower epidermis; (*mlb*) median line bundle; (*uep*) upper epidermis. × 35.

Fig. 35. Transverse section of the young leaf at its margin showing the anticlinal division in the epidermal cell. Note the absence of mesophyll cells; (*lep*) lower epidermis. × 410.

Fig. 36. Transverse section of the furled leaf near the margin showing the cell initial (*a*) of the mesophyll and division of one of the protodermal cells; (*lep*) lower epidermis; (*uep*) upper epidermis. × 410.

Fig. 37. Transverse section of the furled leaf near the margin showing daughter cells (a^1 and a^2) from the division of the mesophyll initial. × 410.

PLATE 6

Fig. 38. Transverse section of a young leaf near the margin of the blade showing the initial cell to a median provascular strand; (lep) lower epidermis; (*uep*) upper epidermis. × 410.

Fig. 39. Transverse section of the furled leaf showing the daughter cells of the first division of the provascular strand initial; (*lep*) lower epidermis; (*uep*) upper epidermis. × 410.

Fig. 40. Transverse section of the furled leaf showing further divisions of the cells of the provascular bundle strand; (*lep*) lower epidermis. × 410.

Fig. 41. Transverse section of the young leaf blade showing the differentiated young provascular bundle strand (shaded); (*uep*) upper epidermis. × 410.

Fig. 42. A still older provascular bundle strand (*prbs*). × 410.

Fig. 43. Transverse section of the young leaf near the margin of the blade showing two young median line bundles; (*lep*) lower epidermis; (*prbs*) provascular bundle strand. × 228.

Fig. 44. A young bundle showing differentiated xylem vessel (*xy*); (*mlb*) median line bundle. × 228.

Fig. 45. Transverse section of an older median line bundle showing differentiation of the phloem region (*ph*); (*m*) mesophyll; (*xy*) the xylem vessels. × 228.

Fig. 46. A still older median line bundle; (*m*) mesophyll; (*ph*) phloem region; (*xy*) xylem vessels. × 228.

PLATE 7

Fig. 47. Transverse section of well-differentiated median line bundle; (*m*) mesophyll; (*pbc*) phloem bundle cap; (*ph*) phloem; (*xbc*) xylem bundle cap; (*xy*) xylem vessels. × 228.

Fig. 48. Transverse section of the young leaf near the margin of the blade showing the daughter cells of the peripheral provascular bundle initial; (*m*) mesophyll; (*lep*) lower epidermis. × 228.

Fig. 49. Transverse section of the young leaf showing a much older peripheral provascular bundle strand; (*lep*) lower epidermis; (*perb*) peripheral bundle. × 228.

Fig. 50. Cross section of a still older peripheral bundle; (*perb*) peripheral bundle. × 228.

Fig. 51. Cross section of the peripheral bundle with differentiated xylem (*xy*); (*perb*) peripheral bundle. × 228.

Fig. 52. Cross section of a peripheral bundle near the lower epidermis showing the presence of a group of xylem vessels (*xy*); (*perb*) peripheral bundle. × 228.

Fig. 53. Longisection of the young leaf showing the spiral thickenings of the xylem vessels (*xy*) in the bundle. × 228.

PLATE 8

Fig. 54. Transverse section of a mature peripheral bundle showing the well-developed phloem cap; note a rhombohedral crystal in the mesophyll situated just above the bundle. × 292.

Fig. 55. Cross section of a mature peripheral bundle showing the phloem and xylem bundle cap. × 292.

Fig. 56. Transverse section of a young median bundle. × 292.

Fig. 57. A portion of a transverse section of mature leaf showing the small peripheral bundles and the bundles in between the median line and the periphery of the leaf blade. × 69.

Fig. 58. Longisection of the terminal spine showing pits of the sclerenchymatous ground cells. × 292.

Fig. 59. Surface section of the upper epidermis showing the external air-chambers of the stomata. × 292.

Fig. 60. Surface section of the lower epidermis showing the external air-chambers of the stomata. × 292.

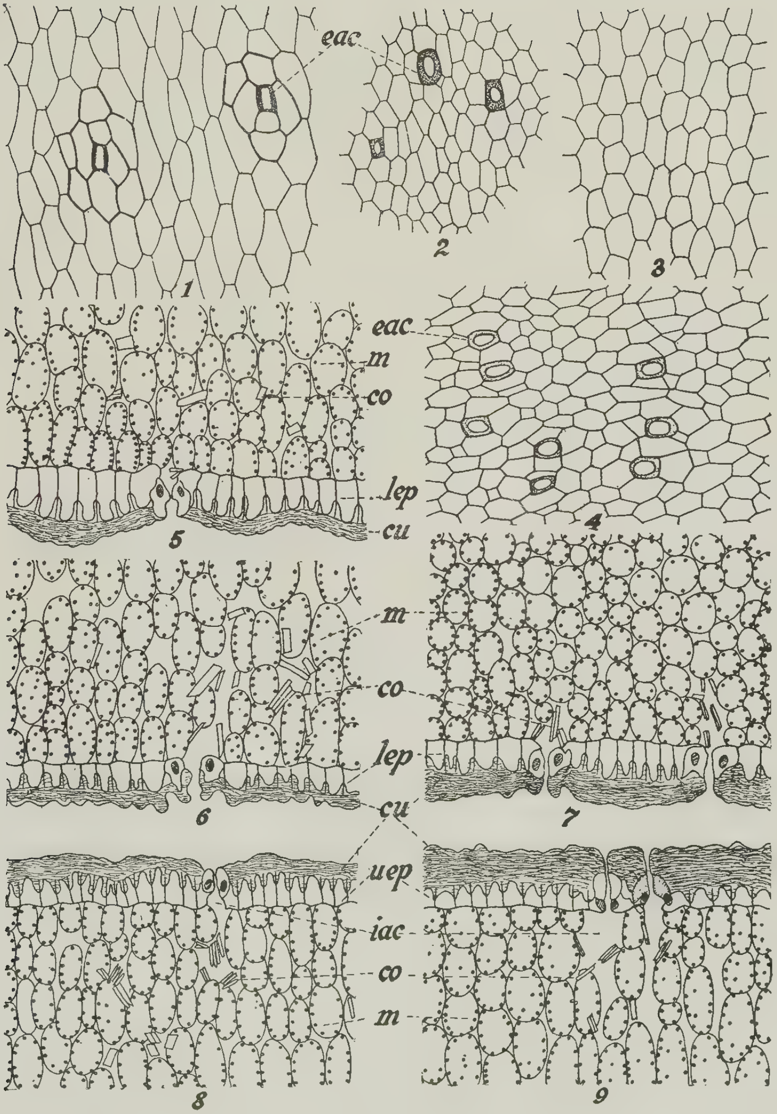

eac
1
2
3
eac
m
co
lep
cu
4
5
m
co
lep
cu
6
7
uep
iac
co
m
8
9

PLATE 1

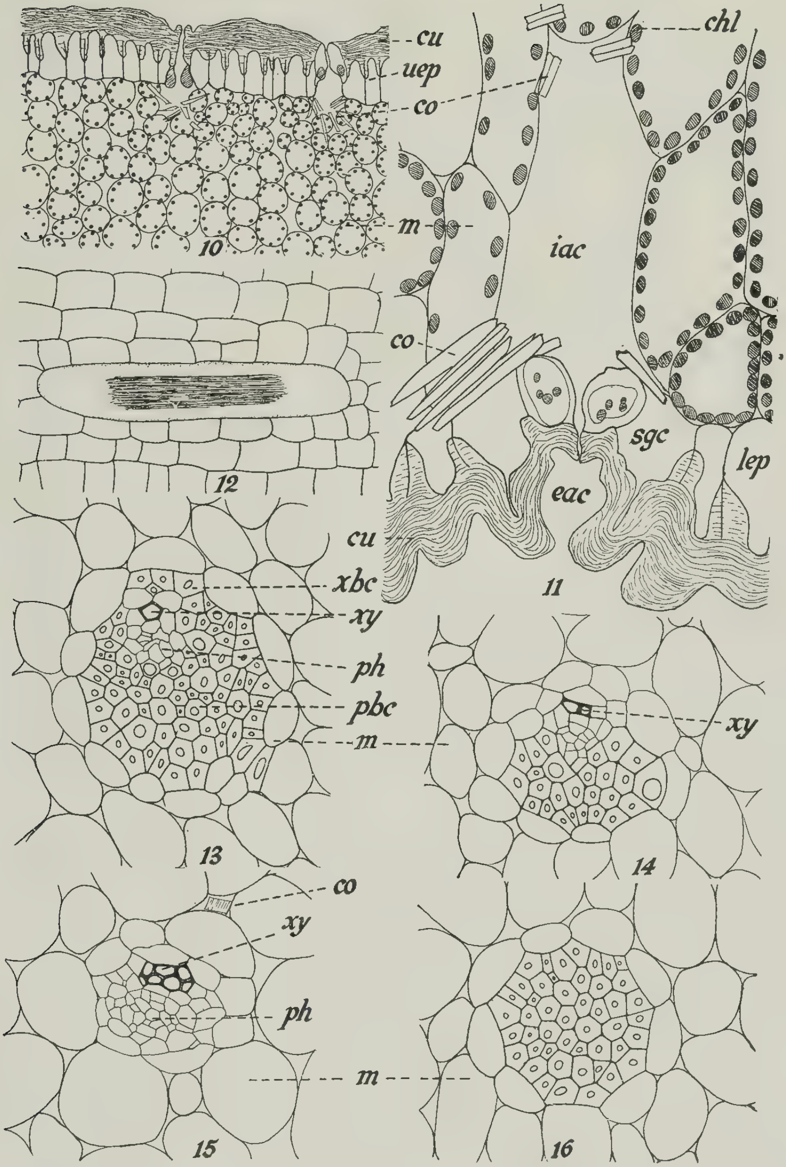
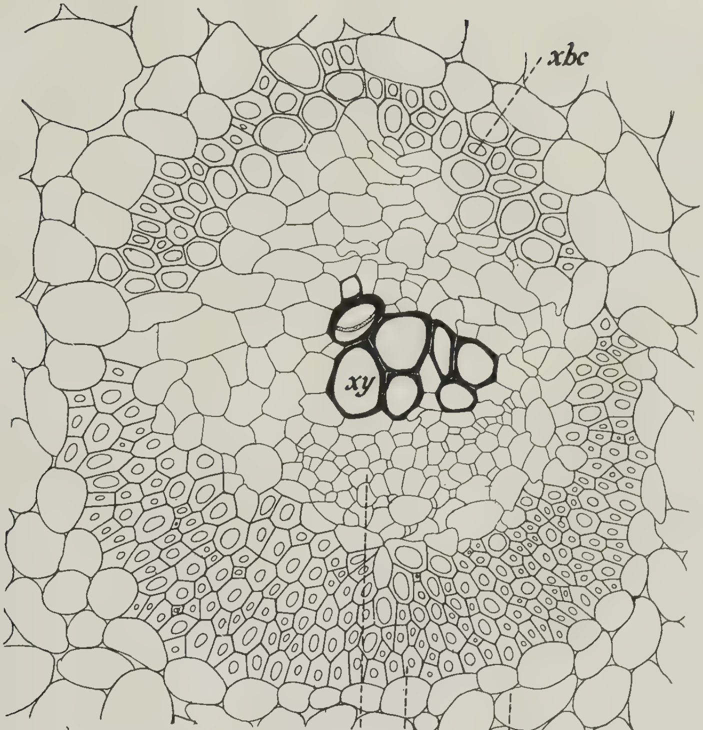
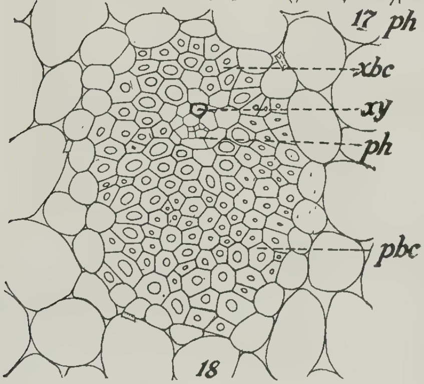

cu
uep
co
m
10
chl
co
iac
co
12
sgc
lep
eac
cu
11
xbc
xy
ph
pbc
m
xy
13
14
co
xy
ph
m
15
16

PLATE 2


xbc
xy
17
ph
pbc
m


xbc
xy
ph
pbc
18

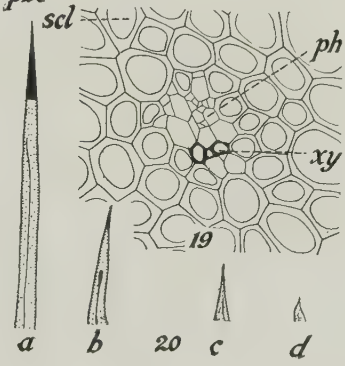

scl
ph
xy
19
a
b
20
c
d

Plate 3

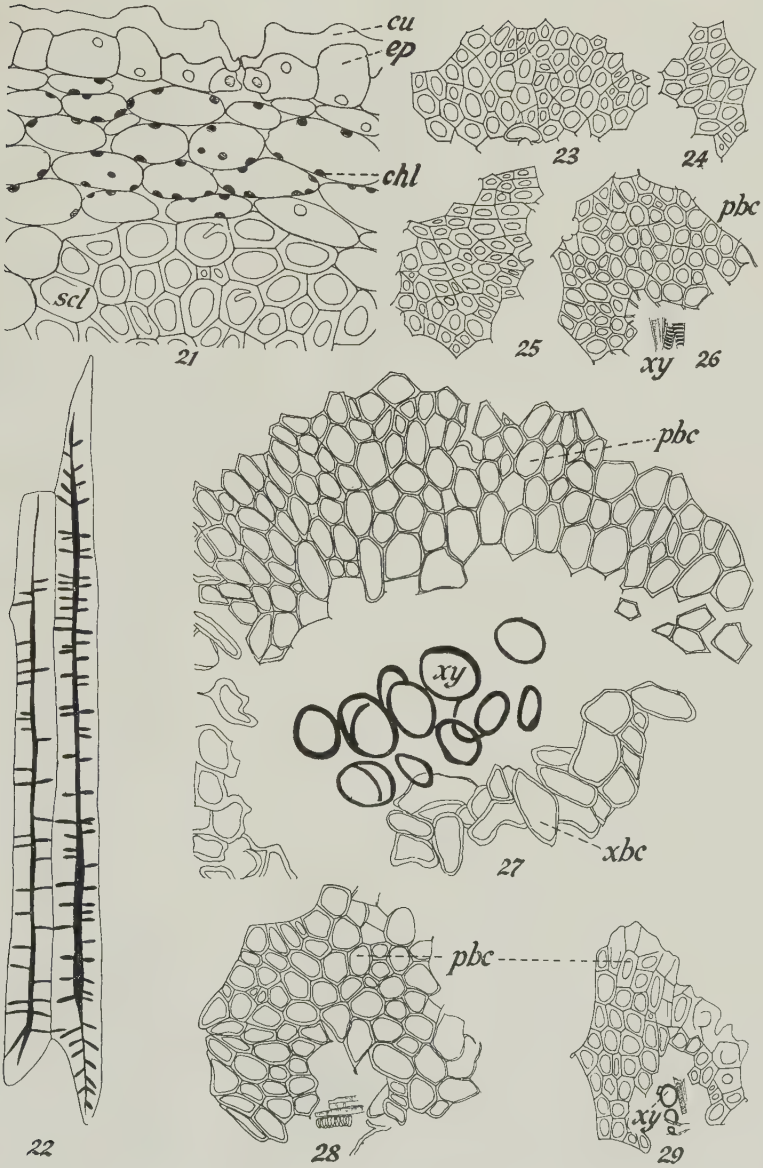

cu
ep
chl
scl
21
23
24
25
pbc
xy
26
22
pbc
xy
xbc
27
pbc
28
xy
29

PLATE 4

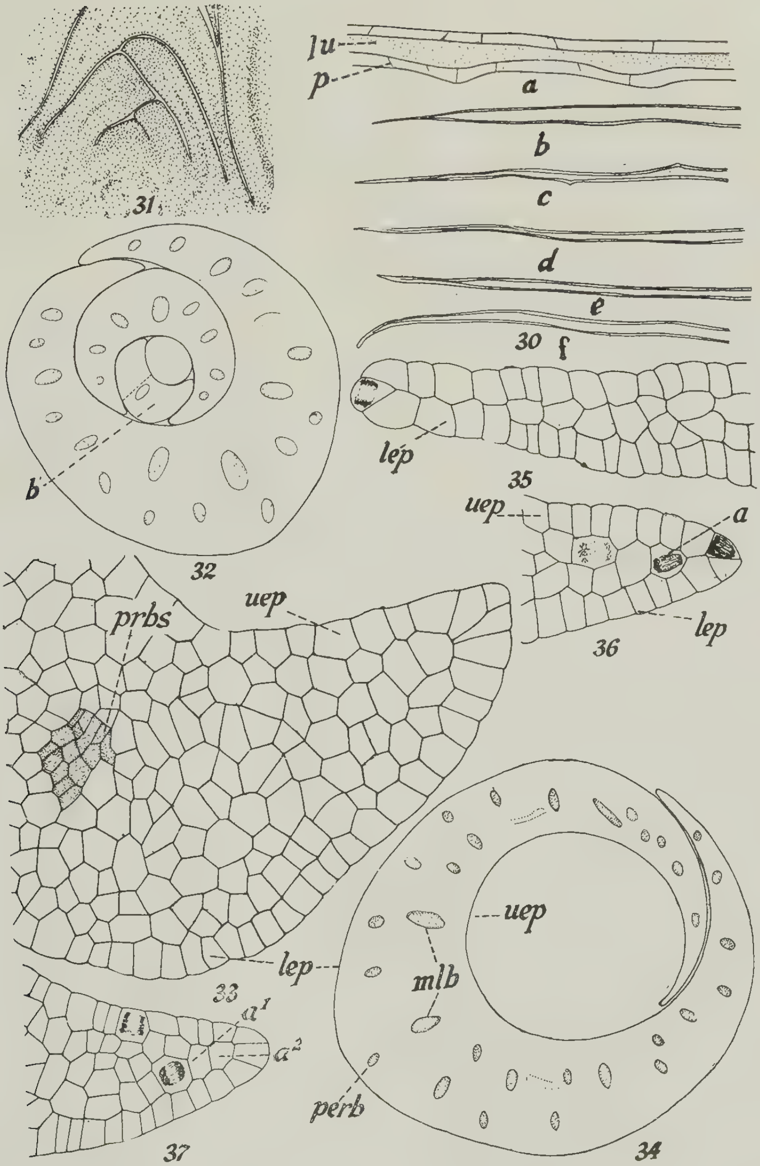

lu
p
a
b
c
d
e
30
f
31
32
b
lep
35
uep
a
lep
36
prbs
uep
lep
33
a¹
a²
37
uep
mlb
perb
34

PLATE 5

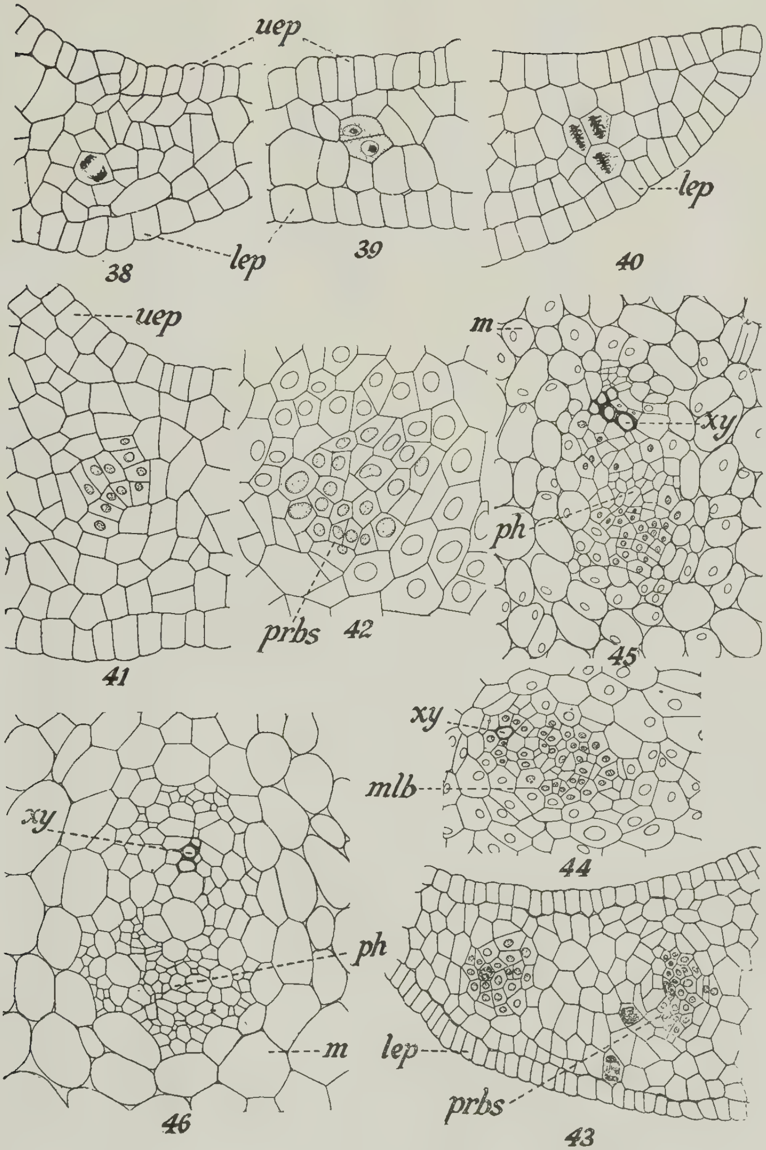

uep
38
lep
39
40
lep
uep
41
prbs
42
m
xy
ph
45
xy
mlb
44
xy
ph
m
46
lep
prbs
43

PLATE 6

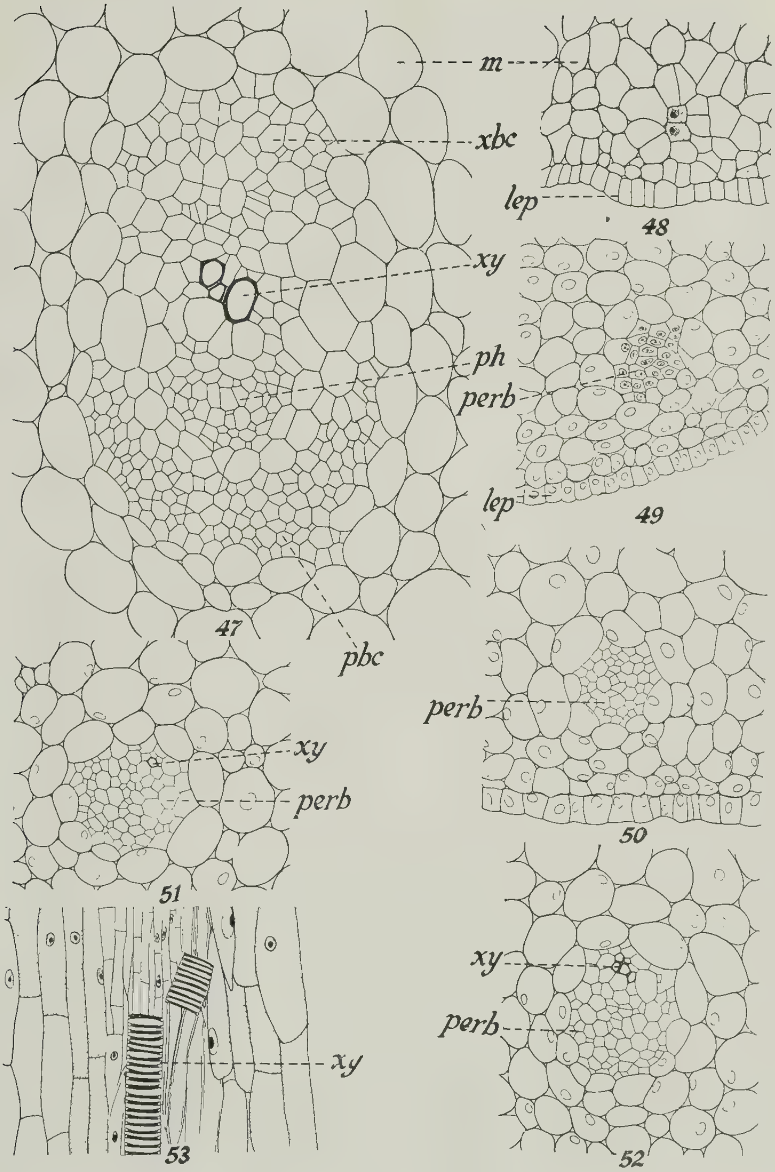
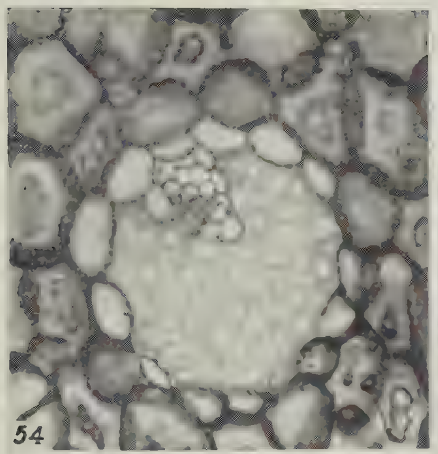
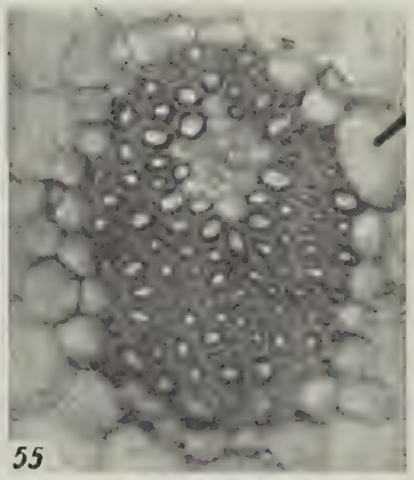
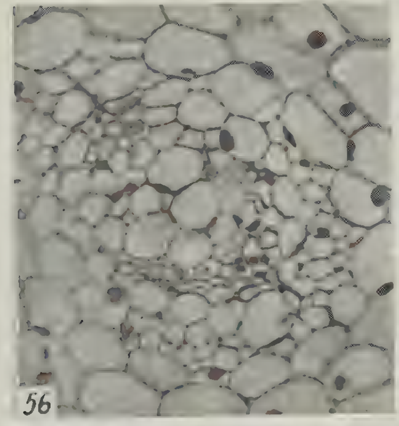
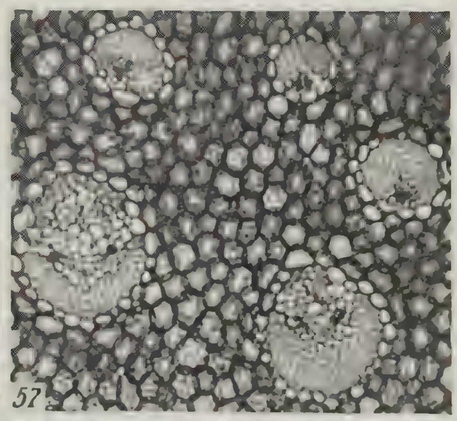

m
xbc
lep
48
xy
ph
perb
lep
49
47
pbc
perb
50
xy
perb
51
xy
perb
xy
53
52

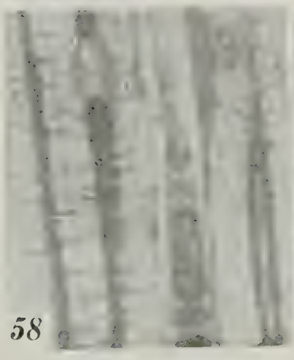
PLATE 7

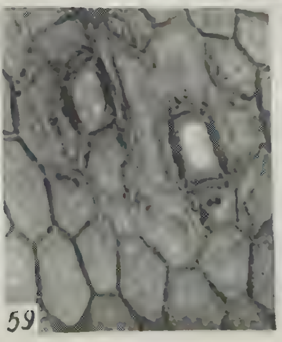

54


55


56


57


58


59

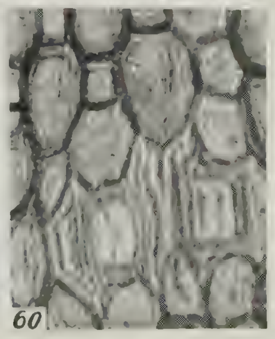

60

Plate 8

TABLE 1

Mean length in centimeters of the different groups of leaves

	GROUP -1 (60° FROM THE MAIN AXIS TO 90°)	GROUP - 2 (30° TO 60°).	GROUP - 3 (0° TO 30°)
Mean	193.115 ± 0.8815	161.390 ± 0.5362	99.27 ± 1.7806
Standard deviation ...	14.90 ± 0.6233	9.10 ± 0.3792	30.227 ± 1.2595
Coefficient of variation	7.715 ± 0.3227	5.638 ± 0.2349	30.442 ± 1.3699

TABLE 2

Tensile strength in kilograms per gram sample of hand-scraped and retted fibers from the three groups of leaves

GROUP NO.	ITEMS	HAND-SCRAPED	RETTED	DIFFERENCE
Group I	Mean	117.834 ± 2.0250	77.051 ± 0.6407	40.783 ± 2.0
	Standard deviation ...	40.279 ± 1.4319	15.58 ± 0.4530	—
	Coefficient of variation	34.182 ± 1.3487	20.22 ± 0.6115	13.962 ± 1.48
Group II	Mean	138.058 ± 1.6658	78.44 ± 1.2227	59.618 ± 2.0
	Standard deviation ...	41.40 ± 1.1779	24.32 ± 0.8645	—
	Coefficient of variation	29.987 ± 0.9265	31.004 ± 1.2013	1.017 ± 1.51
Group III	Mean	132.626 ± 1.9019	82.30 ± 0.9500	50.326 ± 2.0
	Standard deviation ...	40.00 ± 1.3840	19.92 ± 0.6718	—
	Coefficient of variation	30.015 ± 1.1215	24.204 ± 0.8570	5.811 ± 1.61

TABLE 3

Differences in mean tensile strength in kilograms per gram sample[a] of hand-scraped and retted fibers obtained from different groups of leaves

GROUP NO.	HAND-SCRAPED	RETTED
Group II		
Group I	20.224 ± 2.63	1.389 ± 1.30
Group III		
Group I	14.792 ± 2.60	5.249 ± 1.20
Group II		
Group III	5.432 ± 2.50	3.86 ± 1.50[b]

[a] The samples have the constant length of 25.5 cm.
[b] This difference is in favor of Group III.

LIBRARY

A STUDY ON THE NATURE OF WEATHERING OF VOLCANIC TUFFS UNDER LOS BAÑOS CONDITIONS [1]

N. L. Galvez
Of the Department of Soils

Tuffs, or adobe rock, are solidified volcanic fine ejecta produced during the eruption of volcanoes. In a region of great volcanism in the past, the massive rocks within the reach of the ash were covered by tuffs, which served as the soil-forming rocks in the place. Owing to their porosity they yield readily to physical and chemical weathering processes, when exposed to the atmosphere, disintegrate, and decompose. The products formed, generally called unconsolidated soil materials, are finally transformed into soils by biological processes. Volcanic tuffs contribute much to the regolith and soil formation in places where they have completely blanketed the massive rocks.

Abella y Casariego (1885), in an article translated by Blando (1937), reported that the tuffs around Mount Maquiling were very compact and similar to those found in Guadalupe. They were of fine grain, yellowish or brownish gray, and caused the undulated forms of the fields in which they abound. They were composed of a clayey ash-colored paste with pumiceous and feldspathic materials giving rise to the formation of pebbles of basalt or dolerite.

Cox (1908) found that tuffs were very abundant in west central Luzon, covering the area between Lingayen Gulf and the seacoast of Batangas. He stated also that Mr. Ickis mentioned their existence in the Agusan-Pulangi region, inland part of Cagayan, Misamis, and that during the Spanish regime, they were extensively used for building materials. In his microscopical examination of the tuffs near Manila, Cox (1908) found plagioclase, both decomposed and undecomposed, magnetite, hornblende, quartz grains, cementing materials composed largely of oxide of iron, and pumice. Cox's (1908) chemical analysis of samples obtained from quarries near Manila, Guadalupe, and Majayjay showed that with the exception of P_2O_5 and SO_3, which were perhaps not determined, all tuffs contained the chief constituents of common soil-forming rocks as shown in table 1.

---

[1] Experiment Station contribution No. 1367. Read before the Los Baños Biological Club, June 27, 1940.

Adams (1910) stated that the southwestern part of Luzon consisted of plains of water-laid tuffs and higher areas of subaërial formation. Smith (1924) corroborated the findings of Cox (1908) and Adams (1910) on the extent of tuff deposits in Luzon and mentioned their presence in Negros and Cebu. Bandong's[2] conclusions on the mode of formation of tuffs are similar to those of Adams (1910).

A study on the nature of weathering of tuffs was made because the type and properties of the residual soils are influenced largely by the nature of weathering of soil-forming rocks. Data on this phenomenon may help our farmers in diagnosing soil fertility.

MATERIALS AND METHODS

The volcanic tuffs used in the present study were composite samples taken from the lower horizon of the upland farms of the College of Agriculture, Los Baños, Laguna Province. All were yellow and not as hard as ordinary soil-forming rocks. When ignited, they turned brick red. In addition to these, samples of real tuffs or "adobe rocks", which are used for building materials, were analyzed in a similar manner. Unlike the first, these were gray and became dark brown upon ignition.

In order to have an idea of the nature of weathering of volcanic tuffs here in Los Baños, representative samples of residual soils, namely, Lipa clay loam, Los Baños clay loam, and Ibaan clay loam, were likewise studied. All of these soils were brown and turned brick red on ignition. Aquino and Mamisao (1939) and Estioko (1939) reported that the College of Agriculture has a mean temperature, from 1918 to 1937, of 27.1°C. and an annual precipitation of 2,204.6 mm. According to Lang this precipitation is equal to a rain factor of 81.3 (Blanck and Hahelhoff, 1928; Robinson, 1932; Vageler, 1933). Other things being at optimum conditions for soil formation, brown earth could be formed under this rain factor. The color is identical with that of the soil on the upland farms of the College of Agriculture.

The method of chemical analyses for determining the composition of the different samples was similar to that recommended by Rieser (1931).

---

[2] BANDONG TOMAS E. Tuff soils and their origin. (Thesis presented for graduation from the College of Agriculture with the degree of Bachelor of Science in Agriculture. 1926. Unpublished.)

RESULTS AND DISCUSSION

Table 2 shows that samples 1 and 2 contained all the constituents of common soil-forming rocks, namely, SiO_2, TiO_2, Al_2O_3, Fe_2O_3, Mn_3O_4, CaO, MgO, K_2O, Na_2O, SO_3, and P_2O_5. About forty-five per cent of the components of sample 1 and fifty-seven per cent of those of sample 2 were SiO_2. Table 2 also shows that the chemical analysis of sample 2 is much closer to those given in table 1 by Cox (1908) than that of sample 1.

Table 2a shows that the difference in the composition of the two samples was evident only in the mean amount of SiO_2, Fe_2O_3, and loss on ignition, the rest being insignificant. The amount of SiO_2 in sample 2 was significantly greater than that in sample 1, whereas those of Fe_2O_3 and loss on ignition were smaller in the former than in the latter. Therefore, the samples taken from the lower horizon of the soil types studied contained more water of hydration than sample 2.

Table 3, shows that all the constituents of the parent materials, table 2a, were found in appreciable quantity in the weathered materials; hence the latter had not undergone intensive weathering. The relative amount of the different elements in the surface varied from sample to sample. This confirms the common observation that soils are heterogeneous materials. The dominant figures in their decreasing order are SiO_2, Al_2O_3, Fe_2O_3, loss on ignition, CaO, and MgO. The amount of Fe_2O_3 is almost equal to that of loss on ignition. The subsoils, like those of the surface, revealed similar tendencies with the exception that the amount of loss on ignition was decidedly lower than Fe_2O_3. By comparison, the mean composition of the surface and the subsoils differed only in the average value of the loss on ignition, which is significant in favor of the surface soil. This is shown in table 3a. These data may indicate that if the amount of the loss on ignition represented the amount of water of hydration and organic matter, no appreciable alteration or translocation of the mineral contents of the surface and the subsoils would result.

Table 3a presents certain characteristics of the nature of weathering of volcanic tuffs.

According to Eckstein, Jacob, and Alten (1931) Harrassowitz, reported that the molecular ratios SiO_2/Al_2O_3 and $(CaO + Na_2O + K_2O)/Al_2O_3$, are authentic indices of the phenomenon of weathering and absorption of easily soluble salts in the soil, respectively. The first ratio was termed *ki*, and the second, *ba*. Richter (1933) reported that American literature on the subject of weathering preferred using the ratio $SiO_2/(Al_2O_3+Fe_2O_3)$ to SiO_2/Al_2O_3. Because of this, both formulae were used in the interpretation of the chemical data. In addition to the formula given by Harrassowitz for ascertaining the phenomenon of leaching of soil bases, the molecular relation $(CaO + MgO + K_2O + Na_2O)/Al_2O_3$, was also tried.

In assessing and evaluating the values of *ki* (table 3b) in the surface and the subsoil, one may note that they are statistically identical. No mark of distinction in the nature of weathering existed between the surface and the subsoil (table 3c). When the value of *ki*, column 1, in the surface is compared to those in the volcanic tuffs, samples 1 and 2, the differences are all significant (table 3c), in favor of the parent materials. This indicates that in the consolidation of volcanic tuffs into soil, an enormous loss of SiO_2 was incurred. This is also apparent when the subsoils are compared with the tuffs.

The molecular ratios in column 2, although quantitatively dissimilar to those in column 1, support the conclusion drawn from the comparative study of the molecular ratios in the latter.

Table 3c shows that in the values of *ba*, column 3, the surface has apparently a figure identical with that of the subsoil. Because of their close agreement, apparently no appreciable leaching of the soil bases from the surface occurred. The amount washed down during the rainy days may have been brought up again by the capillary rise of the soil solution during the dry days, and during the consolidation of the surface soil, no significant loss of the soil bases, namely, CaO, K_2O, and Na_2O, occurred. On the other hand the values of *ba* of the weathered materials are comparatively lower than those of the parent materials. This reveals that during the weathering, the volcanic tuffs, as shown by the values of *ba*, underwent a considerable removal of the soil bases.

The data obtained by the introduced formula, $(CaO + MgO + K_2O + Na_2O)/Al_2O_3$, are not incompatible with those of *ba*, column 3, in spite of not being of equal degree; that is, the relation of the weathered materials to the parent materials, as revealed by the data obtained by the formula of Harrassowitz, is also ascertained by those derived from the introduced formula.

Tables 3b and 3c, show that the volcanic tuffs in Los Baños, are undergoing laterization. According to Ramann (1911) this is a phenomenon of weathering whereby SiO_2 was the main constituent lost while Al_2O_3 and Fe_2O_3 were being accumulated. The volcanic tuffs under study had all the characteristics of lateritic weathering. Since the soil still retains most of its bases, namely, lime, magnesia, potash, and sodium, the lateritic process is still in its early stage. For this reason crops can be produced for ages without fertilizing.

SUMMARY AND CONCLUSIONS

From the foregoing discussions, the following may be concluded:

1. Lang's method of ascertaining soil types by the use of rain factors (rainfall in millimeters/mean annual temperature) was found to be applicable in Los Baños.

2. Volcanic tuffs contained all the chief constituents of the common soil-forming rocks.

3. The two samples of tuffs used in the present study differed only in the mean amount of SiO_2, Fe_2O_3, and loss on ignition. The samples collected in the lower horizons of the profile of some soil types on the upland farms of the College of Agriculture contained more Fe_2O_3 and loss on ignition than those of real tuffs.

4. The only difference in the chemical composition between the surface and the subsoils was in the amount of loss on ignition. This shows that no material change or translocation of the mineral contents in these two soil horizons occurred.

5. The volcanic tuffs underlying the residual soils of Lipa clay loam, Los Baños clay loam, and Ibaan clay loam were undergoing the process of laterization, which was, however, just beginning.

6. The molecular ratio $SiO_2/(Al_2O_3 + Fe_2O_3)$ can be used interchangeably with SiO_2/Al_2O_3 in ascertaining the nature of weathering of rocks.

7. An enormous loss of easily soluble soil bases was incurred during the process of weathering of tuffs, resulting in the relatively low contents of CaO, MgO, K_2O, and Na_2O in the soils formed.

8. The molecular ratio $(CaO + MgO + K_2O + Na_2O)/Al_2O_3$ may be used in place of $(CaO + K_2O + Na_2O)/Al_2O_3$ in determining the degree of leaching or adsorption of easily soluble salts in the soil.

LITERATURE CITED

ADAMS, GEORGE. 1910. Geologic reconnaissance of Southwestern Luzon. Philippine Jour. Sci. Sec. A. 5: 57–116. *Pl. 1–31; 2 maps.*

AQUINO, D. I., AND J. P. MAMISAO. 1939. Soil survey of the Maquiling area. The Philippine Agriculturist 27: 647–667. *Fig. 1–2; 1 map.*

BLANCK, E., UND E. HASELHOFF. 1938. Lehrbuch der Agrikulturchemie. 3. Teil. Bodenlehre 208 p., mit 3 Textabbildungen. Berlin: Verlag von Gebrüder Borntraeger.

BLANDO, JOSÉ B. (translator) 1937. Mount Maquiling and its present volcanic emissions *by* ENRIQUE ABELLA Y CASARIEGO. The Philippine Agriculturist 26: 199–221.

COX, ALVIN J. 1908. Volcanic tuff as a construction and a cement material. Philippine Jour. Sci. Sec. A. 3: 391–407. *Fig. 1–2.*

ECKSTEIN, O., A. JACOB, UND F. ALTEN. 1931. Arbeiten über Kalidüngung. 237 p., mit 72 Textabbildungen. Berlin SW 11: Verlagsgesellschaft für Ackerbau M. B. H.

ESTIOKO, ROMAN P. 1939. Weather observations at the College of Agriculture, 1924–1937. The Philippine Agriculturist 28: 206–224. *Charts 1–2.*

RAMANN, E. 1911. Bodenkunde. 3rd ed., xv + 619 p., 63 fig. Berlin: Verlag von Julius Springer.

RICHTER, CHARLES. 1933. Ueber hawaiische Bodenbildungen. Inaugural Dissertation 64 p., tables A to G. Göttingen: Gedruckt bei August Schönhütte und Söhnen.

RIESER, A. 1931. Die chemische Gesamtanalyse des Bodens. Handbuch der Bodenlehre 7: 205–238.

ROBINSON, GILBERT WOODING. 1932. Soils, their origin, constitution, and classification. vii + 390 p., 12 fig. London: Thomas Murby and Co.

SMITH, WARREN D. 1924. Geology and mineral resources of the Philippine Islands. 559 p., 39 pl. Manila: Bureau of Printing.

VAGELER, P. 1933. An introduction to tropical soils. xvi + 240 p., 12 pl. London: Macmillan and Co., Ltd.

TABLE 1

Chemical analyses of Philippine tuffs [a]

SOURCE	MANILA	GUADALUPE		MAJAYJAY
	per cent	*per cent*	*per cent*	*per cent*
SiO_2	56.84	56.55	59.27	57.26
TiO_2	Included in Al_2O_3	Included in Al_2O_3	0.83	0.91
Al_2O_3	18.46	22.34	17.06	16.95
FeO	2.51	—	2.61	7.55
Fe_2O_3	0.75	1.87	2.16	
Mn_3O_4	trace	—	trace	0.25
CaO	4.78	4.74	3.37	3.56
MgO	1.59	2.36	1.52	1.10
K_2O	2.72	2.84	3.63	1.86
Na_2O	4.12	2.38	2.49	1.64
SO_3	—	—	—	—
P_2O_5	—	—	—	—
Loss on ignition	6.95	4.86	6.42	7.65
Moisture	1.76	2.51	1.34	1.43
Total	100.48	100.44	100.70	100.14

[a] Cox (1908) gave these data.

TABLE 2

Chemical analyses of tuffs

	SAMPLE 1 [a]—TUFFS COLLECTED IN THE LOWER HORIZON OF THE RESIDUAL SOILS. COLOR—YELLOW				SAMPLE 2 [b]—REAL TUFFS COLOR—BROWNISH GRAY			
	C_1	C_2	C_3	C_m	S_1	S_2	S_3	S_4
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
SiO_2	44.86	42.21	46.00	48.86	57.07	56.00	59.08	57.81
TiO_2	1.00	0.88	0.74	0.96	1.12	0.54	0.76	1.00
Al_2O_3	22.74	24.00	20.60	19.94	18.00	22.86	17.32	18.80
Fe_2O_3	11.06	12.00	12.02	10.54	7.40	7.70	7.50	5.30
Mn_3O_4	trace	trace	0.30	0.22	0.10	trace	trace	0.15
CaO	4.65	4.40	4.34	3.50	5.00	3.95	4.50	4.20
MgO	2.62	1.93	2.21	1.89	2.12	1.74	2.05	1.95
K_2O	2.00	2.12	2.50	2.31	2.70	1.89	2.67	3.00
Na_2O	1.95	1.76	1.86	1.42	1.20	1.00	1.25	1.84
SO_3	0.88	1.12	0.79	0.50	0.74	0.60	0.50	0.81
P_2O_5	0.35	0.56	0.40	0.29	0.22	0.35	0.45	0.46
Loss on ignition .	8.25	9.00	7.90	10.00	4.02	4.00	4.05	4.50
Total	100.36	99.98	99.66	100.43	99.69	100.63	100.13	99.82

[a] C_1 was collected in the C-horizon of Lipa clay loam; C_2, of Los Baños clay loam; C_3, of Ibaan clay loam; C_m, sample collected at random.

[b] S_1 was obtained from the Barrio of Mayondon, Los Baños, Laguna; S_2, from a Chinese store in Bay, Laguna; S_3 and S_4 from a Chinese store in San Pablo, Laguna.

TABLE 2a

Comparison of the mean chemical composition of tuffs

	MEAN CHEMICAL COMPOSITION		DIFFERENCE
	Sample 1	Sample 2	
	per cent	*per cent*	*per cent*
SiO_2	45.48 ± 0.92	57.49 ± 0.44	12.01 ± 1.04
TiO_2	0.90 ± 0.08	0.86 ± 0.12	0.04 ± 0.14
Al_2O_3	21.82 ± 1.24	19.25 ± 1.25	2.57 ± 1.76
Fe_2O_3	11.41 ± 0.37	6.98 ± 0.56	4.43 ± 0.67
Mn_3O_4	—	—	—
CaO	4.22 ± 0.25	4.41 ± 0.24	0.19 ± 0.35
MgO	2.16 ± 0.17	2.00 ± 0.09	0.16 ± 0.19
K_2O	2.23 ± 0.11	2.39 ± 0.27	0.16 ± 0.29
Na_2O	1.75 ± 0.12	1.32 ± 0.20	0.43 ± 0.23
SO_3	0.82 ± 0.13	0.66 ± 0.07	0.16 ± 0.15
P_2O_5	0.40 ± 0.12	0.37 ± 0.21	0.03 ± 0.08
Loss on ignition	8.79 ± 0.47	4.14 ± 0.12	4.65 ± 0.48

TABLE 3

Chemical analyses of the weathered materials from tuffs [c]

	SURFACE SOIL MEAN DEPTH 0-35 CM.				SUBSOIL MEAN DEPTH 35-100 CM.			
	A_1	A_2	A_3	A_m	B_1	B_2	B_3	B_m
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
SiO_2	39.30	41.00	40.62	40.15	40.00	42.00	41.20	40.80
TiO_2	0.50	0.20	0.85	0.38	0.42	0.64	0.34	0.38
Al_2O_3	28.75	25.73	24.85	23.49	27.52	27.00	25.28	26.50
Fe_2O_3	12.25	13.02	13.75	12.88	14.00	12.88	13.88	13.00
Mn_3O_4	0.10	trace	0.20	0.10	trace	trace	trace	trace
CaO	3.50	4.01	3.68	3.48	4.05	3.88	5.00	4.62
MgO	2.21	1.49	2.00	3.00	2.09	1.65	2.14	1.98
K_2O	0.60	0.45	0.65	0.72	0.65	0.82	0.42	0.58
Na_2O	0.54	0.28	0.49	0.41	0.51	0.61	0.28	0.33
SO_3	0.28	0.70	0.35	0.42	0.70	0.81	0.43	0.38
P_2O_5	0.20	0.30	0.46	0.38	0.40	0.49	0.39	0.30
Loss on ignition .	12.06	13.00	11.88	15.08	10.00	9.05	11.05	10.92
Total	100.29	100.18	99.78	100.11	100.34	99.83	100.41	99.79

[c] A_1 and B_1 were the surface and subsoils, respectively of the Lipa clay loam; A_2 and B_2, of Los Baños clay loam; A_3 and B_3, of Ibaan clay loam; A_m and B_m, of sample collected at random.

TABLE 3a

Comparison of the mean chemical composition of the surface and subsoils

	MEAN CHEMICAL COMPOSITION		DIFFERENCE
	Surface soil	Subsoil	
	per cent	*per cent*	*per cent*
SiO_2	40.27 ± 0.38	41.00 ± 0.42	0.73 ± 0.57
TiO_2	0.48 ± 0.14	0.45 ± 0.19	0.03 ± 0.24
Al_2O_3	25.71 ± 1.12	26.58 ± 0.48	0.87 ± 1.21
Fe_2O_3	12.98 ± 0.31	13.44 ± 0.30	0.46 ± 0.43
Mn_3O_4	—	—	—
CaO	3.67 ± 0.12	4.39 ± 0.26	0.72 ± 0.29
MgO	2.81 ± 0.31	1.97 ± 0.11	0.84 ± 0.33
K_2O	0.61 ± 0.06	0.62 ± 0.09	0.01 ± 0.06
Na_2O	0.43 ± 0.06	0.43 ± 0.08	0.00 ± 0.10
SO_3	0.44 ± 0.09	0.58 ± 0.11	0.14 ± 0.14
P_2O_5	0.34 ± 0.06	0.40 ± 0.04	0.06 ± 0.09
Loss on ignition	13.01 ± 0.72	10.26 ± 0.47	2.75 ± 0.86

TABLE 3b

Mean molecular ratio of SiO_2/Al_2O_3 (ki), $SiO_2/(Al_2O_3+Fe_2O_3)$ $(CaO+K_2O+Na_2O)/Al_2O_3$ (ba), and $(CaO+MgO+K_2O+Na_2O)/Al_2O_3$

COLUMN	1	2	3	4
	SiO_2 (ki)	SiO_2	$CaO+K_2O+Na_2O$ (ba)	$CaO+MgO+K_2O+Na_2O$
	Al_2O_3	$Al_2O_3+Fe_2O_3$	Al_2O_3	Al_2O_3
Surface soil	2.69 ± 0.09	2.03 ± 0.07	0.31 ± 0.01	0.53 ± 0.04
Subsoil	2.63 ± 0.04	1.99 ± 0.04	0.35 ± 0.02	0.54 ± 0.02
Volcanic tuffs Sample 1	3.59 ± 0.26	2.64 ± 0.18	0.60 ± 0.03	0.86 ± 0.04
Volcanic tuffs Sample 2	5.10 ± 0.30	4.18 ± 0.26	0.69 ± 0.07	0.95 ± 0.10

TABLE 3c

Comparison of the mean molecular ratios

ITEMS COMPARED	DIFFERENCES			
	SiO_2 (ki)	SiO_2	$CaO+K_2O+Na_2O$ (ba)	$CaO+MgO+K_2O+Na_2O$
	Al_2O_3	$Al_2O_3+Fe_2O_3$	Al_2O_3	Al_2O_3
Surface-subsoil	0.06 ± 0.10	0.04 ± 0.08	0.04 ± 0.02	0.01 ± 0.04
Surface-sample 1	0.90 ± 0.28	0.61 ± 0.19	0.29 ± 0.03	0.33 ± 0.06
Surface-sample 2	2.41 ± 0.31	2.15 ± 0.27	0.38 ± 0.02	0.42 ± 0.11
Subsoil-sample 1	0.96 ± 0.26	0.65 ± 0.18	0.25 ± 0.04	0.32 ± 0.04
Subsoil-sample 2	2.47 ± 0.30	2.19 ± 0.26	0.34 ± 0.07	0.41 ± 0.10

STUDIES ON THE NUTRITIVE VALUE OF THE ELON-ELON RICE VARIETY GROWN IN DIFFERENT PARTS OF THE ISLANDS[1]

JOSÉ R. VELASCO

That environment exerts an important influence on the composition of cereals has been proved in wheat. This prompts the question as to whether rice is similarly influenced by the soil and the climate.

Review of literature

Studies have been made on the influence of the environment on the composition of the wheat kernel. According to Le Clerc and Leavitt (1910), Laws and Gilbert in 1857, at Rothamsted, found that a long growing period after heading gave a plump grain with a low percentage of nitrogen.

Shaw and Walters (1911), reported that Schindler believed that the composition of the grain depends upon the fertility of the soil.

Jensen (1901) pointed out that the size of the grain decreased as the climate became more "continental", that is, a cold and dry winter, rain in late spring and early summer, and a high temperature at harvest. As the size decreased, the percentage of nitrogen increased. Insular or coast climates produced wheats high in starch, low in gluten, but plump and soft.

Wiley (1901) believed that "one of the principal seasonal influences affecting the composition of the wheat grain, and probably also of other cereals, is the length of the period of growth. There appears to be a marked relation between the content of protein matter and starch and the length of the growing season. The shorter the period of growth and the cooler the climate the larger the content of protein and the smaller the content of starch, and vice versa."

Le Clerc and Leavitt (1910) concluded that "wheat of the same variety obtained from different sources and possessing widely different chemical and physical characteristics, when grown side by side in one locality, yields crops which are almost the same in appearance and in composition. Wheat of any one variety, from any one source and absolutely alike in chemical and physical characteristics, when grown in different localities possessing different climatic conditions, yields crops of very widely different appearance and very different chemical composition. These differences are due, for the most part, to climatic conditions prevailing at the time of growth. The results so far obtained would seem to indicate that the soil and seed play a relatively small part in influencing the composition of crops."

---

[1] Experiment Station contribution, No. 1368. Prepared in the Department of Agricultural Chemistry under the direction of Professor F. O. Santos.

Shaw and Walters (1911) in corroboration with Le Clerc and Leavitt state: "It appears that the nitrogen content of an original seed when grown elsewhere than in a climate within which it has been acclimated has little or no influence upon its progeny, and that even though it be acclimated, still some seasonal climatic factor is sufficient either to lower the nitrogen content of a high-gluten wheat or raise the nitrogen content of a low-gluten wheat."

In 1914, Le Clerc and Yoder found that climate had the preponderating influence on the composition of the wheat crop. They suggested that the humidity, rainfall, sunlight, and temperature might affect the metabolic processes of the plant; or the physical, chemical, or biological characteristics of the soil might be altered, thus modifying the nutrition of the plant.

Gericke (1920) claimed that the low protein content of the wheats from the Pacific States was not due primarily to climate but "to the insufficiency of available nitrogen at certain growth period of the plants. That climate is not without effect upon the availability of the plant food in the soil is obvious, but the emphasis to be laid on the climatic complex is that it affects the nutrition of the plant. This can be both in the kind and quantity of each of the different nutrients that may be available to it."

Waldron (1933) showed that comparative plumpness in wheat was modified mainly by heat and moisture conditions. He further observed that the shortness of the growing season was evidently only one factor in bringing about low protein content.

According to Shutt and Hamilton (1934), in general, the excellent quality of the wheat of the prairie provinces was very largely due to the favorable seasonal conditions, which included high temperature and absence of excessive moisture during the later stages of development of the grain. "Favorable seasonal conditions are fully equal in importance to desirable inherited characteristics and exceedingly fertile soil."

Malloch and Newton (1934) found that high yield was associated with low protein content. In some cases, however, a concurrent increase in both yield and protein content occurred.

Hopkins (1935) believed that the nitrogen content of the grain is largely determined by conditions prevailing prior to the onset of translocation.

Juliano (1940) found that environment exerted a significant influence on the botanical characteristics of the Guinangang rice variety. He determined the composition of the samples in order to verify the reason for some people's preference "for rice obtained from one locality over the same kind harvested in other places:" and, whether the products would have "nearly identical nutritive qualities, immaterial of their place of origin." A great divergence was found in the constituents of the samples. The author deduced that some degree of correlation existed between soil fertility as expressed in mean average height of the plants and the ash content of the hulled grains.

Objects of this study

The objects of this study were to determine the proximate analyses of samples of the Elon-elon variety of rice from different regions of the Philippines, and to find some possible explanations for the difference, if any existed.

Time and place

The work was started in April, 1939, and was completed in February, 1940. All analyses were performed in the laboratory of the Department of Agricultural Chemistry, College of Agriculture, University of the Philippines.

MATERIALS AND METHODS

Rice samples

Because Elon-elon is a good export variety of rice, and because it is beginning to be widely grown throughout the Philippines, it was used as the material in this investigation. Thirty rice samples were gathered from widely distributed places in the Philippines. The samples were obtained, as much as possible, from the agricultural supervisor of each province. When the supervisor could not supply it, efforts were made to obtain it from friends. While in the laboratory, care was taken to keep the materials free from pests and diseases by storing them in air tight containers. They were all air-dried. No sample came from a field artificially fertilized. Data on irrigation of the fields where the samples were raised were not available.

Description of materials

Table 1 shows the origin of the samples, the approximate date of planting and harvesting, and the yield per hectare and per cavan of seeds. The majority of the data on yield, however, was merely estimated. Farmers do not have an accurate knowledge of the yield because of the prevalent practice of the "share system" of harvesting among the rice-producing provinces.

The sample from San Vicente, Butuan, Agusan was raised in a very low place with standing water, whereas that from Libertad, Butuan, Agusan came from a field depending solely on the heavy rain that fell in January and February.

Procedure

The official methods for proximate analysis of cereals of the Association of Official Agricultural Chemists (Skinner, 1935) were followed, except in the determination of ash.

a. Edible portion. Each of the samples was divided into two portions, which were then weighed separately. Each portion was pounded in an iron mortar, and the hull separated from the kernel. The cleaned kernel was weighed to get the edible portion.

b. Preparation of the sample for analysis. The edible portion was powdered in an iron mortar and passed through a 40-mesh sieve. Some of the powdered mass was separated by quartering and put in a weighing bottle.

c. Ash. Since the official method of ashing was tedious and fusion of samples was frequent, tests were made on the modifications suggested by two workers. The magnesium acetate method of Bailey (1937) and the magnesium nitrate method of Working and Anderson (1935) were run side by side with the official method. Of the two methods, Bailey's gave results approaching the official method. Bailey's method consists essentially in adding 3 ml. of alcoholic magnesium acetate solution (6 grams of the anhydrous salt per liter) to about 3 grams of the sample and incinerating the mixture in a muffle furnace at 700°C. Blanks were run to determine the amount of ignited salt.

RESULTS AND DISCUSSIONS

The results are presented in tables 1, 2, 3, 4, 5, and 6. Most of the data in table 1 were supplied by the collector of the material, usually the agricultural supervisor of the province.

With the exception of the edible portion, which was run in duplicate, and the nitrogen-free extract, which was obtained by difference, all the analytical data in table 2 were averages of quadruplicate determinations.

In table 4, the different samples were grouped according to climate. The samples from the first type (according to the "Climate of the Philippines," [Anonymous, 1939]) were made a group by themselves—the distinct dry and wet. Those from the regions of the second, third, and fourth types of climate were placed under the uniform-climate group. This was done because the last three types were more or less similar to each other in that they had an evenly distributed rainfall; besides that, the samples representing these types were few.

The data on soil nitrogen (table 5) were obtained from the Division of Soil Survey, Department of Agriculture and Commerce. The soil samples were obtained from the town where the corresponding grain sample was secured; however, whether both of them came from exactly the same section of the town was not known.

The data on rainfall during the growing period of the crop in table 6 were obtained from the Meteorological Bulletin for 1938, by Doucette of the Weather Bureau. Some of the data were kindly supplied by the Director of the Weather Bureau in a personal correspondence. Those marked "only approximate" were the rainfall for that period in the station of the Weather Bureau nearest the locality where the sample was secured.

Since most of the samples were raised by farmers who kept little or no record of their farm operations, variations in the length of the growing season could not be definitely ascertained (table 1).

Edible portion. The wide divergence in edible portion (table 2) may be attributed to the influence of the environment. Not enough data was on hand, however, to warrant assigning the differences to any particular factor.

Moisture. Le Clerc and Yoder (1914) hinted that among other factors the rainfall may have an influence on the composition of the wheat crop. It was thought interesting to follow up this suggestion and find whether the rainfall for the growing season was correlated with the moisture content of the grain. An insignificant correlation existed between them (table 6). One probable explanation is that since the samples were produced in the lowland, the standing water in the field might have affected whatever influence the rainfall had exerted.

Ash. Table 3 shows that the difference between the maximum and the minimum ash content was very significant. Except in one case the other differences were significant.

Fats. The two samples from Agusan had unusually high percentages of fat. In spite of this, the difference between the average fat contents of the two climatic groups was insignificant (table 4).

Crude fiber. A significant difference occurred between the sample from Hagonoy, Bulacan and that from Sibalom, Antique. These two samples had the maximum and minimum percentages, respectively (table 3). The crude fibers of the two climatic groups (table 4) showed an insignificant difference.

Proteins. Table 3 indicates that a significant difference occurred between the highest and the lowest percentages of proteins. In the comparisons made, only four differences were insignificant.

The difference in the protein contents of the two climatic groups was significant (table 4). The cooler and wetter the region, the higher is the protein content. This is in apparent contradiction to the results on wheat of Le Clerc and Yoder (1914). They found that Kansas, a relatively dry region, yielded wheat with a high protein content, whereas California, a more humid place, produced wheat with a low protein content.

The conclusion of Gericke (1920) on the relation of nitrogen in the soil and the protein of the wheat grains suggested the probability of the same condition existing in rice. Data on the total nitrogen of the soil from different localities were obtained from the Division of Soil Survey, Department of Agriculture and Commerce to verify this. Table 5 shows that an insignificant correlation ($r = -0.056$) existed between the nitrogen content of the soil and that of the rice. This result is in accord with those of Shaw and Walters (1911).

A more thorough study on this point is necessary in order to make a general conclusion.

Nitrogen-free extract. A significant difference was found between samples of the two climatic groups (table 4). From the same table, it may be deduced that an inverse relation existed between the protein and the nitrogen-free extract contents.

SUMMARY AND CONCLUSIONS

1. Thirty samples of the Elon-elon variety of rice collected from different places in the Islands were analyzed for proximate composition.

2. Differences in composition were found between samples. The edible portion ranged from 58.38 to 74.43, with an average of 68.14 ± 0.434 per cent; moisture, from 11.328 ± 0.236 to 16.385 ± 0.091, with an average of 13.291 ± 0.132 per cent; ash, from 0.692 ± 0.019 to 1.701 ± 0.012, with an average of 1.058 ± 0.028 per cent; proteins from 6.336 ± 0.112 to 9.730 ± 0.066, with an average of 7.208 ± 0.121 per cent; fats, from 0.509 ± 0.008 to 3.407 ± 0.035, with an average of 1.365 ± 0.081 per cent; crude fibers from 0.461 ± 0.003 to 1.021 ± 0.007, with an average of 0.682 ± 0.018; and nitrogen-free extract, from 72.456 to 78.611, with an average of 76.337 ± 0.185 per cent.

3. The highest protein-containing sample was secured from San Vicente, Butuan, Agusan; the highest fat-containing sample, from Libertad, Butuan, Agusan; and the sample with the highest nitrogen-free extract, from Batangas, Batangas.

4. No significant correlation was found between the soil nitrogen and the protein content of the grain.

5. The moisture content of the grain had no significant correlation with the rainfall during the growing season.

6. The average protein content of rice from the region of uniform climate was significantly higher than those from the distinct dry and wet regions; the converse was found in nitrogen-free extract content.

LITERATURE CITED

ANON. 1939. Climate of the Philippines. P. I. Dept. Agric. Comm. 31 p. 1 fig.

BAILEY, L. H. 1937. Some observations on methods of ashing cereal products. Cereal Chem. 14: 120–128.

DOUCETTE, B. F. 1939. Meteorological bulletin for May to December, 1938. Philippine Weather Bur. Meteorol. Bull. 1938: 93–292.

GERICKE, W. F. 1920. On the protein content of wheat. Science 52: 446–447.

HOPKINS, J. W. 1935. Influence of weather conditions on the nitrogen content of wheat. Canada Jour. Res. 13: 127–133.

JENSEN, J. L. 1901. On the relation of climate to size of grain of cereals. *Cited in* U. S. Exper. Sta. Rec. 12: 737–738, 1900–1901.

JULIANO, J. B. 1940. A study of the growth habit of rice plants: IV. Locality and grains. The Philippine Agriculturist 28: 605–625.

LE CLERC, J. A., AND S. LEAVITT. 1910. Tri-local experiments on the influence of environment on the composition of wheat. U. S. Dept. Agric., Bur. Chem. Bull. 128: 1–18.

Le Clerc, J. A., and P. A. Yoder. 1914. Environmental influences on the physical and chemical characteristics of wheat. Jour. Agric. Res. **1**: 275-291.

Malloch, J. G., and R. Newton. 1934. The relation between yield and protein content of wheat. Canada Jour. Res. **10**: 774–779.

Shaw, G. W., and E. H. Walters. 1911. A progress report upon soil and climatic factors influencing the composition of wheat. California Agric. Exper. Sta. Bull. 216: 1–23.

Skinner, W. W. 1935. Official and tentative methods of analysis of the Association of Official Agricultural Chemists. 4th ed., xix + 691 p., 52 fig. Washington, D. C.: A. O. A. C.

Shutt, F. T., and S. N. Hamilton. 1934. The quality of wheat as influenced by environment. Empire Jour. Exper. Agri. **2**: 119–138. *Cited in* Chem. Absts. **28**: 6768.

Waldron, L. R. 1933. Yield and protein content of hard red spring wheat under conditions of high temperature and low moisture. Jour. Agric. Res. **47**: 129–147.

Wiley, H. W. 1901. Influence of environment on the chemical composition of plants. U. S. Dept. Agric. Yearbook **1901**: 299–318.

Working, E. B., and E. J. Anderson. 1934. Quick ash methods. Cereal Chem. **11**: 94–98.

TABLE 1

Field information on the samples

PLACE GROWN	DATE PLANTED	DATE HARVESTED	YIELD PER HECTARE	YIELD PER CAVAN
			cavans	*cavans*
Libertad, Butuan, Agusan	Sept. 11, 1938	March 22, 1939	50–60	50–60
San Vicente, Butuan, Agusan	Sept. 5, 1938	March 20, 1939	60	60
Sibalom, Antique	May 15, 1938	Dec. 18, 1939	62	56
Balayan, Batangas	July 1, 1938	Jan. 5, 1939	34	34
Batangas, Batangas	Aug. 28, 1938	Jan. 10, 1939	60.5	35.8
Ubay, Bohol	July , 1938	Nov. , 1938	45	
Hagonoy, Bulacan	July , 1938	Dec. , 1938	40	50
Malolos, Bulacan	July , 1938	Dec. , 1938	39	48
Aparri, Cagayan	July , 1938	Feb. , 1939	58	58
Naga, Camarines Sur	July , 1938	Dec. , 1938	35	
General Trias, Cavite	Aug. 29, 1938	Jan. 16, 1939	60	66
Tanza, Cavite	Aug. 10, 1938	Jan. 26, 1939	63	65
Ajuy, Iloilo	Sept. , 1938	Jan. , 1939	70–80	
Santiago, Isabela	Sept. , 1938	Feb. , 1939	56	56
Biñan, Laguna	Aug. , 1938	Dec. , 1938	68	
Agricultural College, Laguna	Aug.–Sept., 1938	Jan. 25, 1939		72.4
Lumbatan, Lanao	July 25, 1938	Feb. 15, 1939	67	72
Central Luzon Agricultural School, Nueva Ecija	July 20, 1938	Jan. 4, 1939	57.5	67
Quezon, Nueva Ecija	July 10, 1938	Jan. 24, 1939	80	98
San Isidro, Nueva Ecija	June 5, 1938	Dec. 20, 1938	60–80	60–100
Bayombong, Nueva Vizcaya	Aug. , 1938	Jan. , 1939	60	60
Bacolor, Pampanga	July , 1938	Jan. , 1939	62	
Santa Barbara, Pangasinan	June 1, 1938	Dec. 12, 1938	56	
Tayug, Pangasinan	July 4, 1938	Jan. 10, 1939	55	60
Tanay, Rizal	July 15, 1938	Jan. 29, 1939	60	63.5
Tarlac, Tarlac	Aug. , 1938	Jan. , 1939	61	
Tiaong, Tayabas	July 10, 1938	Jan. 26, 1939	49	33
San Marcelino, Zambales	July , 1939	Dec. , 1939	35	
Margosatubig, Zamboanga	Aug. , 1938	Feb. , 1939	50	
Pagadian, Zamboanga	July , 1938	Jan. , 1939	55	
Average			59.5	59.5

TABLE 2

Analysis of the rice samples from different parts of the Philippines

ORIGIN OF SAMPLES	EDIBLE PORTION	MOISTURE	ASH	PROTEINS	FATS	CRUDE FIBER	NITROGEN-FREE EXTRACT (By difference)
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Distinct dry and wet:							
Sibalom, Antique .	74.43 ^{h}	13.306±0.075	0.737±0.003	7.061±0.075	0.882±0.006	0.461±0.003 ^{l}	77.553
Balayan, Batangas	68.10	13.252±0.109	1.033±0.008	8.340±0.079	1.255±0.006	0.699±0.009	75.421
Batangas, Batangas	63.34	11.756±0.053	0.692±0.019 ^{l}	7.234±0.027	1.206±0.013	0.501±0.003	78.611 ^{h}
Hagonoy, Bulacan .	72.45	12.227±0.072	1.320±0.009	8.575±0.021	1.128±0.016	1.021±0.007 ^{h}	75.729
Malolos, Bulacan .	68.92	12.477±0.062	1.218±0.012	7.250±0.042	1.517±0.011	0.594±0.002	76.944
Gen. Trias, Cavite.	68.22	11.821±0.055	0.762±0.008	7.486±0.059	1.775±0.001	0.468±0.012	77.788
Tanza, Cavite	60.59	13.030±0.022	0.952±0.009	7.151±0.193	1.234±0.012	0.668±0.025	76.965
Biñan, Laguna ...	66.36	14.037±0.077	1.151±0.009	6.858±0.068	0.846±0.009	0.760±0.009	76.348
Agricultural College, Laguna ...	70.00	13.697±0.048	1.050±0.151	8.104±0.029	0.798±0.010	0.784±0.006	75.567
C. L. A. S., Nueva Ecija	73.34	12.924±0.054	1.428±0.008	6.664±0.267	0.657±0.011	0.878±0.004	77.449
Quezon, Nueva Ecija	71.12	12.442±0.041	0.899±0.007	8.042±0.059	0.727±0.021	0.878±0.004	77.192
San Isidro, Nueva Ecija	71.00	12.333±0.079	0.879±0.014	6.818±0.061	1.816±0.008	0.662±0.004	77.502
Bacolor, Pampanga	70.73	12.374±0.055	1.185±0.010	6.784±0.045	1.609±0.007	0.666±0.011	77.385
Santa Barbara, Pangasinan	66.24	13.512±0.103	1.120±0.011	6.847±0.011	0.849±0.014	0.701±0.009	76.971
Tayug, Pangasinan	67.74	12.847±0.079	0.949±0.010	6.336±0.112 ^{l}	1.195±0.009	0.558±0.009	78.115
Tanay, Rizal	70.23	14.424±0.044	1.197±0.008	7.072±0.034	0.629±0.005	0.928±0.015	75.750
Tarlac, Tarlac ...	66.83	14.962±0.059	1.236±0.012	7.170±0.074	1.136±0.025	0.714±0.007	74.792
San Marcelino, Zambales	69.97	13.424±0.062	1.011±0.006	6.539±0.076	1.516±0.008	0.542±0.006	76.968
Uniform climate:							
Libertad, Butuan, Agusan	68.91	12.953±0.254	0.919±0.006	8.307±0.051	3.407±0.035 ^{h}	0.637±0.005	73.777
San Vicente, Butuan, Agusan ...	66.68	12.549±0.058	1.105±0.012	9.730±0.066 ^{h}	3.255±0.020	0.909±0.013	72.456 ^{l}

TABLE 2 (continued)

ORIGIN OF SAMPLES	EDIBLE PORTION	MOISTURE	ASH	PROTEINS	FATS	CRUDE FIBER	NITROGEN-FREE EXTRACT (By difference)
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Naga, Camarines Sur	58.38 *l*	16.385±0.091 *h*	1.237±0.003	7.409±0.121	1.088±0.018	0.639±0.009	73.242
Aparri, Cagayan .	68.85	13.033±0.068	1.092±0.008	8.350±0.050	1.461±0.006	0.669±0.003	75.395
Ajuy, Iloilo	68.47	14.102±0.049	1.701±0.012 *h*	8.021±0.200	1.118±0.020	0.981±0.012	74.077
Santiago, Isabela .	68.65	14.193±0.089	0.976±0.013	7.258±0.051	0.509±0.008 *l*	0.678±0.006	76.286
Bayombong, Nueva Vizcaya	69.93	13.558±0.082	0.997±0.015	8.605±0.069	1.116±0.011	0.568±0.008	75.156
Ubay, Bohol	69.14	11.328±0.236 *l*	1.145±0.010	9.589±0.058	1.721±0.002	0.715±0.009	75.502
Lumbatan, Lanao .	64.82	12.902±0.070	1.123±0.005	9.074±0.021	1.521±0.019	0.663±0.007	74.717
Tiaong, Tayabas .	68.60	13.882±0.053	0.866±0.007	7.237±0.050	1.605±0.004	0.509±0.006	75.901
Margosatubig, Zamboanga	74.19	14.569±0.081	0.865±0.007	6.454±0.004	1.666±0.019	0.671±0.008	75.775
Pagadian, Zamboanga	68.12	14.452±0.046	0.920±0.002	6.971±0.034	1.723±0.020	0.535±0.005	75.399
Average	68.14±0.434	13.291±0.132	1.058±0.028	7.208±0.121	1.365±0.080	0.682±0.018	76.337±0.185

l — lowest.
h — highest.

TABLE 3

Comparison between maximum and minimum constituents

ORIGIN OF SAMPLES	COMPARISON	PERCENTAGE	DIFFERENCE
Moisture:			
1. Naga, Camarines Sur (Max.)		16.385 ± 0.091	
2. Ubay, Bohol (Min.)	(1):(2)	11.328 ± 0.236	5.057 ± 0.253 (S)
3. Tarlac, Tarlac	(1):(3)	14.962 ± 0.049	1.423 ± 0.103 (S)
4. Batangas, Batangas	(2):(4)	11.756 ± 0.053	0.428 ± 0.242 (I)
5. Gen. Trias, Cavite	(2):(5)	11.821 ± 0.055	0.493 ± 0.242 (I)
6. Hagonoy, Bulacan	(2):(6)	12.227 ± 0.072	0.899 ± 0.246 (S)
Ash:			
1. Ajuy, Iloilo (Max.)		1.701 ± 0.012	
2. Batangas, Batangas (Min.)	(1):(2)	0.692 ± 0.019	1.009 ± 0.022 (S)
3. Central Luzon Agricultural School, Nueva Ecija	(1):(3)	1.428 ± 0.008	0.273 ± 0.014 (S)
4. Sibalom, Antique	(2):(4)	0.737 ± 0.003	0.045 ± 0.019 (I)
5. General Trias, Cavite	(2):(5)	0.762 ± 0.008	0.070 ± 0.021 (S)
Proteins:			
1. San Vicente, Butuan, Agusan (Max.)		9.730 ± 0.066	
2. Tayug, Pangasinan (Min.)	(1):(2)	6.336 ± 0.112	3.394 ± 0.130 (S)
3. Ubay, Bohol	(1):(3)	9.599 ± 0.058	0.131 ± 0.088 (I)
4. Lumbatan, Lanao	(1):(4)	9.074 ± 0.021	0.656 ± 0.069 (S)
5. Margosatubig, Zamboanga	(2):(5)	6.454 ± 0.004	0.118 ± 0.112 (I)
6. San Marcelino, Zambales	(2):(6)	6.539 ± 0.076	0.203 ± 0.135 (I)
7. Central Luzon Agricultural School, Nueva Ecija	(2):(7)	6.664 ± 0.267	0.328 ± 0.289 (I)
8. Bacolor, Pampanga	(2):(8)	6.784 ± 0.045	0.448 ± 0.121 (S)
Fats:			
1. Libertad, Butuan, Agusan (Max.)		3.407 ± 0.035	
2. Santiago, Isabela (Min.)	(1):(2)	0.509 ± 0.008	2.898 ± 0.036 (S)
3. San Vicente, Libertad, Agusan	(1):(3)	3.255 ± 0.020	0.152 ± 0.040 (S)
4. Tanay, Rizal	(2):(4)	0.629 ± 0.005	0.120 ± 0.009 (S)
Crude fiber:			
1. Hagonoy, Bulacan (Max.)		1.021 ± 0.007	
2. Sibalom, Antique (Min.)	(1):(2)	0.461 ± 0.003	0.560 ± 0.008 (S)
3. Ajuy, Iloilo	(1):(3)	0.981 ± 0.006	0.040 ± 0.009 (S)
4. General Trias, Cavite	(2):(4)	0.468 ± 0.012	0.007 ± 0.012 (I)
5. Batangas, Batangas	(2):(5)	0.501 ± 0.003	0.040 ± 0.004 (S)

(I) —Insignificant.
(S)—Significant.

TABLE 4

Analysis of data from the standpoint of climate

CONSTITUENTS	DISTINCT DRY AND WET	UNIFORM CLIMATE	DIFFERENCE
	per cent	*per cent*	*per cent*
Moisture	13.047 ± .139	13.659 ± .246	0.612±0.282 (I)
Ash	1.045 ± .010	1.079 ± .045	0.034±0.046 (I)
Protein	7.341 ± .120	8.084 ± .204	0.843±0.236 (S)
Fat	1.154 ± .062	1.682 ± .168	0.528±0.179 (I)
Crude fiber	0.628 ± .023	0.681 ± .027	0.053±0.036 (I)
N. F. E.	76.831 ± .163	74.807 ± .240	2.029±0.290 (S)

(I)—Insignificant.
(S)—Significant.

TABLE 5

Soil nitrogen and protein of rice, compared

ORIGIN OF SAMPLES	SOIL NITROGEN	PROTEIN
	per cent	*per cent*
Balayan, Batangas	0.09	8.340
Batangas, Batangas	0.18	7.234
Hagonoy, Bulacan	0.11	8.575
Malolos, Bulacan	0.14	7.250
General Trias, Cavite	0.16	7.486
Tanza, Cavite	0.11	7.151
Biñan, Laguna	0.14	6.858
Agricultural College, Laguna	0.13	8.104
C. L. A. S., Nueva Ecija	0.11	6.664
Quezon, Nueva Ecija	0.10	8.042
San Isidro, Nueva Ecija	0.14	6.818
Bacolor, Pampanga	0.18	6.784
Santa Barbara, Pangasinan	0.06	6.847
Tayug, Pangasinan	0.12	6.336
Tanay, Rizal	0.16	7.072
Tarlac, Tarlac	0.09	7.170
San Marcelino, Zambales	0.06	6.539

Coefficient of correlation (r) = –0.0568 (insignificant).

TABLE 6

A comparison of rainfall during the growing season and moisture content of rice

ORIGIN OF SAMPLES	RAINFALL	MOISTURE
	mm.	*per cent*
Sibalom, Antique	4,099.5	13.306
Balayan, Batangas	1,087.0[b]	13.252
Batangas, Batangas	1,228.6	11.756
Ubay, Bohol	1,006.4[b]	11.328
Naga, Camarines Sur	1,608.4	16.385
General Trias, Cavite	1,256.8[b]	11.821
Tanza, Cavite	1,256.8[b]	13.030
Ajuy, Iloilo	1,157.9	14.102
Biñan, Laguna	1,338.6[b]	14.037
Agricultural College, Laguna	1,293.9	13.697
C. L. A. S., Nueva Ecija	1,886.5	12.924
Quezon, Nueva Ecija	1,275.5[b]	12.442
San Isidro, Nueva Ecija	1,244.0[b]	12.333
Bacolor, Pampanga	1,251.7[b]	12.374
Santa Barbara, Pangasinan	1,639.4[b]	13.512
Tanay, Rizal	2,048.4[b]	14.424
Tarlac, Tarlac	1,286.7	14.962
Tiaong, Tayabas	1,702.4[b]	13.882
San Marcelino, Zambales	2,911.5[b]	13.424

[b] Only approximate.

Coefficient of correlation (r) = 0.1539 (insignificant).

A STUDY OF JARAGUA GRASS AS A FORAGE CROP[1]

ALEJANDRO O. OBILLO

One of the introduced forage plants that show promising results for feeding is the jaragua grass. This grass has been referred to under a number of other names, such as molasses grass, Brazilian grass, stink, Brazilian stink, gordura, yaragua, yaraguay, and efwatakala (Thursfield, 1922; Whittet, 1924 Milsum, 1926, and Munro, 1930.) Its botanical name is *Melinis minutiflora* Beauv. Because little is known locally about its growth and value, this work was undertaken.

Piper (1911) reported that the plant had the odor of molasses, but both horses and cattle ate it readily as soon as they were used to it. This grass does not grow so rapidly as guinea grass and if cut too close does not always thrive. Molasses grass cannot compete with guinea grass as green fodder, at least during the dry season; and for hay, it cures with difficulty. Piper stated further that its value in pasture as well as its behavior during rainy periods remains to be determined.

Thursfield (1922) wrote "This grass has an appearance very similar to para grass, but has a stronger odor and some stock do not at first appear to like it. It grows like a crab grass at first throwing out horizontal suckers which connect with the ground by root at every joint, the central root becomes very thick and powerful and it is difficult to pull it out of the ground even with considerable force. With this grass has become thick it grows to a height of about 3 feet and forms a close mat which effectually prevents anything from growing under it. When fed to horses and mules some took it at once and some after a little time. Now, all eat it readily and it appears to improve their condition."

Whittet (1924) stated that the methods of propagation of molasses grass are by planting rooted cuttings, runners, or divisions of the main root stem. According to this author, "being a tropical grass it requires a long summer season with heavy rainful land good soil conditions to produce a large amount of growth. Stock are not partial to this plant, mainly because it is extremely hairy; the hairs exude a sticky oil which has a strong musky odor. Stock as a general rule do not find strong smelling plants palatable and invariably refuse to eat them. Cattle feeding on this grass were less subjected to ticks."

---

[1] Experiment Station contribution No. 1369. Prepared in the Departments of Agronomy and Animal Husbandry under the directions of Assistant Professor Vicente B. Aragon (Agronomy) and Associate Professor Valente Villegas (Animal Husbandry).

Milsum (1926) reported that cuttings of molasses grass taken from the horizontal stems and planted two feet apart gave a total yield of about 22,893 kgm. per hectare. He stated further that when the grass was fed fresh to working Siamese bullocks these animals consumed 22.72 to 27.27 kgm. a day. The cattle ate the grass greedily. Guinea grass and napier grass had been fed previously and the animals appeared to relish the molasses grass equally well.

Munro (1930) describes the habit of growth of this plant as follows: "The habit of growth of this grass resembles that of para grass. It does not, however, send out runners like para grass. When sown thickly it spreads out and the bunches coalesce forming a continuous stand about four feet high with stems interlaced and top open to receive moisture, never lying flat so as to shed rain." He pointed out that in pastures it will not stand continuous use but recovers quickly when rested after close grazing.

Sanvictores (1933) reported that gordura grass has all the excellent elements or qualities for fattening cattle, but it is less highly recommended for horses and mules because it can not give them the strength and resistance which is obtainable from other grasses. The author stated further that cattle, Philippine carabaos, and Indian buffaloes eat it voraciously and leave the ground clean. Some horses do not eat it readily at first, but they soon learn to relish it.

The objects of this investigation were: (*a*) To determine the best planting season for jaragua grass as indicated by its yield; (*b*) to find out its palatability for cattle; and (*c*) to ascertain the proximate constituents of both soilage and hay of this grass.

The work was carried on in the Departments of Agronomy and Animal Husbandry, College of Agriculture, from June, 1932, to February, 1934.

MATERIALS

Jaragua grass. The planting materials consisted of cuttings of jaragua grass which originated from the plants brought by former Dean B. M. Gonzalez of the College of Agriculture from the Bon̄gabong Stock Farm, Nueva Ecija, on January 11, 1932. This plant was claimed to have been introduced into the Islands in 1911 by C. V. Piper of the United States Department of Agriculture.

The field. The field used in planting jaragua grass during the wet season was 17 by 78 m. covering an area of 1,326 sq. m. The soil was clay loam. The dry season culture was located close to the wet season field and had the same area and similar soil conditions.

Scale. A Fairbanks scale was employed in weighing grass in the harvesting and feeding periods.

Guinea grass. For determining the relative palatability of jaragua grass, guinea grass in bloom was used for comparison.

Rice straw. Rice straw which was baled in February, 1932, was used in finding the comparative palatability of jaragua hay for cattle.

Cattle. In determining the palatability of jaragua grass soilage and hay, five native cattle were employed. All of them were females. They were on the average 9.7 years old and weighed 491.5 kgm.

Barn. A barn with concrete flooring and mangers was used in feeding the cattle for palatability tests. There were stanchions in the barn for keeping the animals in place.

METHODS

Cultures of jaragua grass. The wet season culture was started on July 7, 1932, and the dry season culture on December 23, 1932.

Preparation of the land. The land was plowed and harrowed on June 16, 1932. A week later it was plowed and harrowed for the second time, and another week later, plowed and harrowed for the third time. Rows one meter apart were then laid out.

Planting. Cuttings about 30 cm. long were used in planting. They were planted 40 cm. apart in the row with five cuttings to a hill.

Weeding and cultivation. The plants were weeded and cultivated when they were about 30 cm. high. The native hoe was used for weeding and a fine-tooth cultivator for cultivation. Weeding and cultivation were resorted to whenever necessary until the plants had fully covered the surface of the ground.

Harvesting. The wet season culture was harvested in November, 1932, and the dry season culture in May, 1933. The plants were cut about 10 cm. above the ground. The cut grass was weighed and the yield determined. The same grass was used for feeding cattle in connection with the palatability test. Harvesting of soilage was made daily.

Curing. The materials for hay making were taken from the shoots of the wet season culture. Curing was done under a shed. The grass was spread on the floor and was turned over several times until it was thoroughly cured.

For the purpose of determining the percentage of hay that can be made from fresh jaragua grass, five samples were taken. They were weighed soon after they were cut in the field and again after curing in the shed. Curing lasted for 25 days.

Preparation of samples for analysis. Samples from fresh materials of jaragua and guinea grass were taken at random and submitted for analysis. Both grasses were then in bloom. Samples were also taken from jaragua hay and rice straw.

Preliminary feeding trials. Before the actual feeding test was undertaken, there was a preliminary feeding trial for a period of five days in each test. This feeding was for the purpose of acquainting the animals with the new feed they were to take.

Palatability test. In order that the palatability of fresh jaragua grass might be determined, it was fed to cattle side by side with guinea grass. Both the jaragua and guinea grasses were in bloom at the time of feeding. In finding out the palatability of jaragua hay, a different method was followed. The jaragua hay was fed in the morning and the rice straw with which it was compared was given in the afternoon. This method was deemed advisable because the animals showed indifference towards jaragua hay.

The morning supply of fresh jaragua and guinea grass was given at six o'clock. More grass was given to the animals from time to time; hence they had all they could consume. At 6:00 p. m. the left-over was removed and weighed. The difference in weight between the amount given and that remaining in the manger represented the amount eaten by the animals. With jaragua hay, the feed was given at 6:00 a.m. and at noon the left-over was removed. Soon after, the rice straw was given to the animals and by 6:00 p.m. the remaining feed was removed. The difference between the amount of feed given and the amount left in the manger in each case represented the amount consumed by the animals. The cattle were watered both morning and afternoon.

Weighing the animals. The animals were weighed at the beginning and at the end of each feeding trial. This was necessary to determine any untoward effect that the feed might have on the condition and health of the animals.

FIELD OBSERVATIONS

Wet season culture. Three to four weeks after the cuttings were planted shoots began to appear. The growth of the plants was rapid. They showed a creeping habit, producing many branches which formed roots at the nodes. The most rapid growth seemed to be from July to September when there was abundant rain. The plants attained an average height of one and one-half meters. Flowering in this wet season culture occurred in November, 1932.

Dry season culture. About one-third of the cuttings planted in the dry season culture dried up so that the percentage of germination was very low. Also owing to lack of rain, the plants became stunted and were pale green in color, producing only a few branches. The plants flowered in February, 1933.

DISCUSSION OF RESULTS

Comparative yield of the wet and the dry season plantings of jaragua grass

From the wet season planting the production of jaragua grass in 1,326 sq. m. was 1,536 kgm. while the dry season planting gave a yield of 162.2 kgm. from an equal area. From this yield the production per hectare was computed to be 11,581.4 kgm. for the wet season culture and 1,223.00 kgm. for the dry season culture. The greater yield in the wet season culture was of course due to the abundance of rainfall during that season.

Percentage of hay from jaragua grass

The average amount of hay produced from 3 kgm. of fresh jaragua grass was 1.1 ± 0.02 kgm., or 36.3 ± 0.20 per cent. Accordingly, from a hectare of wet season culture of this grass, 4,207 kgm. of hay may be obtained.

Proximate chemical analysis of jaragua soilage

The composition of fresh jaragua and guinea grass is as follows:

Moisture. The percentage of moisture of fresh jaragua grass was 63.50 and that of guinea grass, 66.74.

Ether extract. In this nutrient jaragua grass differed a little from guinea grass, the former giving 1.11 per cent and the latter 1.22 per cent.

Ash. Guinea grass contained a higher percentage of ash than jaragua grass. Guinea grass gave 3.63 per cent and jaragua grass, 2.61 per cent.

Protein. Jaragua grass gave 2.26 per cent protein and guinea grass, 1.51 per cent.

Crude fiber. Jaragua grass contained a higher percentage of crude fiber than guinea grass. Jaragua grass had 15.54 per cent crude fiber and guinea grass, 13.60 per cent.

Nitrogen-free extract. Jaragua grass gave 14.98 per cent nitrogen-free extract and guinea grass, 13.30 per cent.

Calories. The number of calories per 100 grams of fresh jaragua grass was 81.00 and that of guinea grass, 72.00.

Proximate chemical analysis of jaragua hay and rice straw

The following proximate chemical analysis of jaragua hay and rice straw are given:

Moisture. The percentage of moisture of jaragua hay was 13.29 and that of rice straw, 7.10.

Ether extract. Jaragua hay contained a higher percentage of ether extract than rice straw. It contained 2.13 per cent while the rice straw showed only 1.44 per cent.

Ash. Rice straw contained 20.87 per cent ash and jaragua hay, 8.06 per cent ash.

Protein. Jaragua hay had 2.57 per cent protein and rice straw about the same amount, or 2.67 per cent.

Crude fiber. Rice straw contained a higher percentage of crude fiber than jaragua hay, there being 28.22 per cent in the straw and 3.68 per cent in the hay.

Nitrogen-free extract. Jaragua hay contained 70.27 per cent of nitrogen-free extract and rice straw, 39.70 per cent.

Calories. The number of calories per 100 grams of jaragua hay was 319, and that of rice straw, 187.

Palatability of jaragua soilage

The range in the amount of jaragua grass consumed by native cattle (table 1), was from 6.01 kgm., or 27.61 per cent of the total feed consumed in the case of ox No. 244 to 14.01 kgm., or 44.11 per cent, with ox No. 174, the mean being 11.26 ± 0.97 kgm., or 42.57 per cent a day. With guinea grass, the consumption varied from 11.25 kgm., or 52.39 per cent, with ox No. 54 to 17.60 kgm., or 55.88 per cent, with ox No. 174, the mean being 14.83 ± 0.77 kgm., or 57.42 per cent a day. The difference is significant and in favor of guinea grass.

Palatability of jaragua hay

According to table 2 the range in the amount of jaragua hay consumed by cattle was from 1.03 kgm. or 20.07 per cent of the total feed consumed in the case of ox No. 198, to 2.31 kgm., or 29.73 per cent, with ox No. 174, the mean being 1.71 ± 0.16 kgm., or 25.21 per cent a day. With rice straw the minimum amount consumed by the animals was 4.26 kgm., or 79.92 per cent, by ox No. 198, and the maximum quantity was 6.00 kgm., or 77.02 per cent, by ox No. 70, the mean being 5.05 ± 0.21 kgm., or 74.78 per cent a day. It is evident that jaragua hay is unpalatable to cattle, very inferior to rice straw in this respect.

SUMMARY

The results of this work may be summarized as follows:

1. The yield of fresh jaragua grass per hectare was 11,581.44 kgm. with the wet season culture, and 1,223.00 with the dry season planting.

2. At the rate of 36.33 per cent of hay from fresh jaragua grass, the average production of hay per hectare in the wet season culture was 4,207.54 kgm.

3. With guinea grass soilage used as a basis for comparison, jaragua grass was consumed by cattle to the extent of 11.26 ± 0.97 kgm. or 42.57 per cent, and guinea grass, 14.83 ± 0.77 kgm., or 57.42 per cent, per head a day.

4. With rice straw as much as 1.71 ± 0.16 kgm., or 25.21 per cent, of jaragua hay was consumed by cattle as compared with 5.05 ± 0.21 kgm., or 74.78 per cent, of rice straw per head a day; this shows the poor palatability of jaragua hay.

5. Fresh jaragua and guinea grasses have the following proximate chemical composition: moisture, 63.50 and 66.74 per cent; ether extract, 1.11 and 1.22 per cent; ash, 2.61 and 3.63 per cent; protein, 2.26 and 1.51 per cent; crude fiber, 15.54 and 13.60 per cent; nitrogen-free extract, 14.98 and 13.30 per cent; and calories per 100 grams of fresh grass, 81 and 72.

6. The proximate chemical composition of jaragua hay and rice straw is as follows: moisture, 13.29 and 7.10 per cent; ether extract, 2.13 and 1.44 per cent; ash, 8.06 and 20.87 per cent; protein, 2.57 and 2.67 per cent; crude fiber, 3.68 and 28.22 per cent; nitrogen-free extract, 70.27 and 39.70 per cent; and calories per 100 grams, 319 and 187.

LITERATURE CITED

MILSUM, J. N. 1926. Preliminary report on molasses grass. Malayan Agric. Jour. 14: 296–298.

MUNRO, J. N. 1930. Molasses grass. Hawaiian For. Agric. 27: 61–64.

PIPER, V. C. 1911. Forage crops and forage in the Philippines. Philippine Agric. Rev. 4: 404.

SANVICTORES, J. G. 1933. Gordura grass. The Stockman and Farmer 1: 17–29.

THURSFIELD, R. 1922. Yaraguay grass. Jamaica Agric. Soc. Jour. 14: 351–352.

WHITTET, J. N. 1924. Molasses grass (*Melinis minutiflora* Beauv.) Agric. Gaz. New South Wales 35: 431–432.

TABLE 1

The comparative average daily consumption of jaragua and guinea grass by cattle

DATE OF FEEDING	OX NO.	JARAGUA GRASS		GUINEA GRASS	
		Amount consumed	Percentage consumption	Amount consumed	Percentage consumption
1933		*kgm.*		*kgm.*	
Nov. 21–Dec. 1	90	13.15	44.58	16.24	55.41
Nov. 21–Dec. 1	174	14.01	44.11	17.60	55.88
Nov. 21–Dec. 1	198	12.73	48.98	13.23	51.01
Nov. 21–Dec. 1	54	10.44	47.60	11.25	52.39
Nov. 21 Dec. 1	244	6.01	27.61	15.87	72.38
Average	—	11.26 ± 0.9726	42.57	14.83 ± 0.7703	57.42

TABLE 2

The average comparative daily consumption of jaragua hay and rice straw

DATE OF FEEDING	OX NO.	JARAGUA HAY		RICE STRAW	
		Amount consumed	Percentage consumption	Amount consumed	Percentage consumption
1934		*kgm.*		*kgm.*	
Jan 13–22 ...	90	2.13	29.54	5.08	70.45
Jan. 13–22 ...	174	2.31	29.73	5.48	70.26
Jan. 13–22 ...	198	1.03	20.07	4.26	79.92
Jan. 13–22 ...	54	1.35	23.74	4.44	76.25
Jan. 23–Feb. 1	70	1.76	22.97	6.00	77.02
Average	—	1.71 ± 0.1624	25.21	5.05 ± 0.2070	74.78

OBSERVATIONS ON THE INFLUENCE OF VARIOUS METHODS OF FEEDING DUCKLINGS [1]

LORENZO M. ANCHETA

Cruz (1932) compared the value of dried shrimps, fish meal, and snails and found that at the age of twelve weeks ducklings fed with the ration supplemented with dried shrimps were the heaviest, those fed with fish meal were intermediate, and those with snails were the smallest. The ducklings that received the ration supplemented with snails consumed the most feed and were the most expensive to raise.

Shrimp meal, because of its rather high cost and because its supply is rather seasonal, cannot be used freely for duck feeding. In order to determine the optimum amount of fish meal needed in the rations for growing ducklings, Castillo (1938) used this supplement in proportions varying from 5 to 40 per cent of the ration. He reported that 30 per cent fish meal is the optimum amount to use in rations for ducklings. A study of the methods of giving this feed to the birds so as to give the most profitable results appears very timely.

Fortier (1916) recommended that when the ducklings are two days old, they be allowed a little water and milk so that they may just dip their bills in without wetting their bodies. The first feed should be a mash consisting of stale bread soaked in milk, hard boiled eggs, bran, and green feed finely chopped.

Thompson (1922) advised not to feed the ducklings until they are at least thirty-six hours old. He recommended that for the first two days a mixture of equal parts of moistened rolled oats and bread crumbs be given. After the third day, equal parts of wheat bran and corn meal should be added to the first mixture. After this, a ration consisting of two to three parts of wheat bran, one part each of corn meal and wheat middlings, 5 per cent (by weight) of high grade meat scraps, and 10 per cent chopped green feed should be given.

---

[1] Experiment Station contribution No. 1370. Prepared in the Department of Animal Husbandry under the direction of Associate Professor F. M. Fronda.

Waite (1929) stated that young ducklings can be started off with such mixtures as equal parts of bran, corn meal, and middlings, mixed with water, or milk if available. After a few days, chopped green stuff should be added so as to provide proper growth-promoting elements in the ration. Fresh water should be kept close at hand as ducks require water with which to wash down their feed.

Robinson (1924) claimed that ducklings will do very well with a mash similar to that given to hens morning and evening, cabbage to pick at, plenty of drinking water, and a supply of oyster shells always before them. If they have no cabbage, about one third of the mash should be cut clover or alfalfa. The ideal way is to coop them on grass or in a garden where they can get a great deal of green feed and worms.

Lee and Haynes (1923) recommended that during the first week, the ducklings should be fed five times daily with a moist mash consisting of two parts bran, one part corn meal, one part middlings, and one-half part green feed. After the first week, a ration consisting of two parts bran, one part corn meal, one part middlings, two parts green feed, and one part meat scraps should be given. The corn meal in the ration should be gradually increased as the ducklings grow older. Drinking water should be near so that the ducks can eat and drink at the same time.

PLAN OF THE STUDY

A total of 325 ducklings that were artificially hatched from eggs produced in the flocks of the College were used in this study. The experiments were conducted in three sets of five lots each. In the first set, there were 19 ducklings to a lot; in the second, 16; and in the third, 30. Thus, there were 65 ducklings to a lot.

The same ration was used in all the lots except lot 1, the native method, which received "riced corn",[2] palay, fresh shrimp, and fresh snail. The ration of the other lots consisted of the following ingredients, all parts by weight:

Rice bran	56.25	parts
Corn meal	18.75	"
Fish meal	25.00	"

---

[2] "Riced corn" is a literal translation of what the duck raisers call "bigas ñg mais" (Tagalog). It consists of the horny endosperm of the corn kernel, cleaned and polished.

IMPERIAL BUREAU OF PASTURES & FORAGE CROPS × ABERYSTWYTH, GREAT BRITAIN
LIBRARY

The different lots were fed as follows:

LOT NUMBER	TREATMENT
I	Native method
II	Mash uncooked, green feed mixed with the mash
III	Mash uncooked, no green feed
IV	Mash cooked, green feed mixed with the mash
V	Mash cooked, no green feed

In the native method, the ducklings were given boiled "riced corn" for the first six weeks. The birds in this lot were fed four times during the day and two times during the night. After the first week, finely chopped fresh shrimps were given at noon instead of the boiled "riced corn," the amount of shrimps being increased as the ducklings grew older.

After the ducklings were three weeks old, they were fed only once at night. Beginning with the sixth week, the feeding at night was stopped and the ration was changed to palay (unhulled rice) and snails. Palay was fed morning and afternoon, and snails were given two times during the day. This feeding was carried on until the birds were twelve weeks old.

The ducklings in the other lots were fed also four times a day. No additional feed, however, was given to them at night. They were fed in bamboo feeding troughs when the birds were yet small, and later they were fed in petroleum cans cut lengthwise to a height of about six centimeters. Drinking water, changed every time the birds were fed, was accessible at all times. At no time did the ducklings have an opportunity to swim.

A brooder house, the walls of which were made of bamboo and the roof of cogon, was built for the ducklings. This house, 18.5 meters long and 1.7 meters wide, was divided into five compartments of about 1.7 meters square each. Each pen had an adjoining grassy yard, 3.6 meters long and 1.7 meters wide. Lakeshore sand was placed as litter in each of the compartments, with rice straw which was changed from time to time on top.

RESULTS AND DISCUSSION

Rate of growth. The weekly weight of the ducklings was used as the criterion in determining the comparative effects of the different methods of feeding on the rate of growth. The average weekly weights of the ducklings are given in table 1.

By reference to table 1, it may be seen that the ducklings in each lot weighed about the same at the beginning of the experiment. From the second week, however, some variations in the average weight became noticeable. Lots I and V were inferior to lots II, III, and IV. These three lots had more or less similar weights. At the age of four weeks, the differences between the weights of the ducklings in lots I and V were well marked when compared with those in lots II, III, and IV which also had more or less similar weights at this period. At the age of eight weeks, the ducklings in lot II were the heaviest. Lot I was lighter than lot II by 281.9 ± 24.704 grams and lot V was lighter than lot II by 94.3 ± 26.545 grams, both differences being significant. The ducklings in lots III and IV were also significantly heavier than those of lots I and V. No significant differences were observed between lots II, III, and IV.

At the close of the feeding trial when the ducklings were 12 weeks old, those in lots II, III, and IV were practically of the same weight, and the differences between them were not significant. The lots that differed significantly were lot I and lot II. lot I being 252.7 ± 25.523 grams lighter than lot II, and lots I and III, the difference between these two lots being 249.7 ± 32.327 grams. Lot I was lighter than lot IV by 250.3 ± 27.019 grams, and than lot V by 125.0 ± 28.353 grams. Lot V was 127.7 ± 17.535 grams lighter than lot II, 134.7 ± 31.658 grams lighter than lot III, and 125.3 ± 26.193 grams lighter than lot IV.

Cruz (1932) reported 519.1 grams as the average weight of the ducklings he raised following the native method. In the present study, the birds given the same treatment had an average weight of 968.6 grams at the same age. That the ducklings in lot I, native method, were the smallest may be expected. This was probably due to the fact that the birds in this lot were not able to consume a sufficient amount of proteins in the feed. They ate the snails including the shell, a very bulky feed, so that even though their crops were filled, they received but little nutriment.

According to Henry and Morrison (1929), cooking feed decreased the digestibility of the proteins in the feed. This may be the reason the birds in lot V did not grow as fast as those in lots II, III, and IV. Bolivar (1928) found that pigs receiving cooked feed were less vigorous than those receiving uncooked feed. Savella (1936) observed similar results with chicks.

In lot IV, the final weight of the birds was more or less the same as that of the birds in lots II and III. This probably was due to the addition to the ration of green feed which made up the deficiency of the constituents destroyed in cooking the mash.

Amount of feed consumed. It was observed that lot V consumed the most feeds, amounting to 693.46 kilograms, or 6.93 kilograms per bird; lot IV was second, consuming 653.23 kilograms, or 6.52 kilograms per bird; lot III was third, consuming 608.75 kilograms, or 6.08 kilograms per bird; and lot II, the least, consuming only 578.85 kilograms, or 5.78 kilograms per bird. In lot I, the birds consumed 195.00 kilograms "riced corn," 74.00 kilograms palay, 125.00 kilograms fresh shrimps, and 965.00 kilograms fresh snails. That the birds receiving cooked mash consumed more feed than those receiving uncooked mash may be attributed to the increased palatability of the mash when cooked. It may be seen that the addition of green feed to the ration reduced the consumption of the birds in lots II and IV.

Mortality. The percentage of mortality in the three trials made and the averages are given in table 2. This table shows that lot I had an average mortality of 31.37 ± 12.096; lot II, 43.98 ± 4.461; lot III, 47.67 ± 5.366; lot IV, 45.09 ± 4.977, and lot V, 59.39 ± 2.313. Lot V, therefore, had the highest mortality and lot I, the lowest. Mortality of the ducklings occurred mostly during their first week of life. At this age, they were very susceptible to cold. It is surprising to note that although the ducklings in lot I did not grow as fast as those in the other lots, yet their mortality was low. This was probably due to the fact that the birds in this lot ate their feed readily from the beginning, whereas those of the other lots took only a little of the feed given to them.

In the first two trials, lot I registered the lowest mortality. In the third trial, a very high mortality was registered in all the lots, probably because there was more rainfall at that time than during the first and second trials.

Returns above cost of feed. The returns above feed cost in the different lots, computed by subtracting the cost of feed from the value of weanlings produced from 100 ducklings calculated at ₱0.50 a kilogram, are shown in table 3.

By reference to table 3, it may be seen that, based upon the returns above the cost of feed, the best lot was lot II, followed by lot IV. Lot II was fed uncooked mash with green feed, and lot IV was fed cooked mash also with green feed. The lowest returns above the cost of feed was obtained in lot V. These results show that the best method of feeding ducklings is by giving them uncooked mash and allowing them free access to all the green feed that they will eat. This system not only produced heavier birds than the native method, but it also reduced the amount of feed consumed and consequently produced the largest returns from the sale of the ducklings above the cost of feed.

Minor observations. There was no appreciable difference in the health and vigor of the ducklings in the different lots. All of them were active, and were observed to be equally nervous. This was particularly true when they were growing their feathers at the age of two months. It was observed that the ducklings in lots II, III, and IV were completely feathered when they were two months old. On the other hand, the ducklings in lots I and V did not complete their feathering until towards the end of the experiment when they were about twelve weeks old.

SUMMARY AND CONCLUSIONS

1. The ducklings that received uncooked mash with or without green feed grew faster than those fed by the native method.
2. The addition of green feed to the cooked mash produced as good growth as did the uncooked mash.
3. Cooking the mash increased the amount of feed consumed.
4. The addition of green feed to the ration reduced the amount of feed consumed.
5. No economic advantage resulted from cooking the mash.
6. The method used in lot 1 (native method) was the most expensive among those tried for raising ducklings.
7. The highest mortality was observed in the lot that received cooked mash without green feed, and the lowest, in the snail lot or native method.
8. There was no appreciable difference in the health and vigor of the ducklings in the different lots studied.
9. With growth as the criterion, feeding uncooked mash was the best method tried and the native method, the poorest.
10. The results obtained in these studies show that the best method of feeding ducklings is by giving them uncooked mash and allowing them free access to all the green feed that they will eat. This system not only produced heavier birds than the native method, but it also reduced the amount of feed consumed, and consequently produced the largest returns from the sale of the ducklings above the cost of feed.

LITERATURE CITED

BOLIVAR, SALVADOR F. 1928. A study on the preparation of hog ration as related to growth and development of pigs. The Philippine Agriculturist **17**: 367–380.

CASTILLO, JOSÉ V. 1938. Determination of the optimum amount of fish meal in rations for growing ducklings. The Philippine Agriculturist **27**: 18–30. *Chart 1–2.*

CRUZ, GAUDENCIO B. 1932. Studies on the methods of feeding ducks. The Philippine Agriculturist **20**: 535–548. *Chart 1.*

FORTIER, VICTOR. 1916. Duck raising. Canada Dominion Exper. Farms Exhib. Cir. 29: 1–4. *Fig. 1–2.*

HENRY, W. A., AND F. B. MORRISON. 1929. Feeds and feedings. Abridged. 6th ed., viii + 440 p., 114 fig. Milwaukee: C. N. Gasper Company.

LEE, A. R., AND SHEPPARD HAYNES. 1923. Duck raising. U. S. Dept. Agric. Farmers' Bull. 697: 1-22.

ROBINSON, J. H. 1924. Management of ducks. Domestic birds. x + 317 p., 236 fig. Dayton, Ohio: The Reliable Poultry Journal Publishing Company.

SAVELLA, HILARION S. 1936. A comparative study of various methods of feeding chicks. The Philippine Agriculturist 25: 452–461. *Chart 1.*

THOMPSON, W. C. 1922. Raising ducks and geese on New Jersey farms. New Jersey Agric. Exper. Sta. Bull. **10**: 1–4.

WAITE, R. H. 1929. Ducks. Poultry science and practice. 1st ed., ix + 433 p., 337 fig. New York: McGraw-Hill Book Co., Inc.

TABLE 1

Average weekly weights of the ducklings in the different lots

AGE	LOT I		LOT II		LOT III		LOT IV		LOT V	
	Native method		Mash uncooked, with green feed		Mash uncooked, no green feed		Mash cooked, with green feed		Mash cooked, no green feed	
	Number of ducklings	Average weights	Number of ducklings	Average weights	Number of ducklings	Average weights	Number of ducklings	Average weights	Number of ducklings	Average weights
	unit	*grams*	*unit*	*grams*	*unit*	*grams*	*unit*	*grams*	*unit*	*grams*
1 day old	65	38.2 ± 0.304	65	37.6 ± 0.320	65	39.0 ± 0.425	65	38.6 ± 0.361	65	38.5 ± 0.365
1 week old	63	52.1 ± 0.724	41	49.9 ± 0.842	41	52.4 ± 0.952	43	54.7 ± 0.959	43	52.9 ± 1.434
2 weeks old	62	85.0 ± 1.981	39	100.2 ± 2.631	39	97.1 ± 5.715	40	98.5 ± 2.662	38	93.0 ± 2.323
3 weeks old	53	127.9 ± 4.618	37	153.5 ± 4.562	37	150.6 ± 5.913	38	152.1 ± 5.214	35	132.3 ± 3.717
4 weeks old	46	187.4 ± 6.692	36	260.1 ± 7.203	36	259.7 ± 9.037	36	259.2 ± 8.007	32	221.0 ± 7.305
5 weeks old	46	284.0 ± 11.062	36	400.7 ± 10.518	35	412.9 ± 12.987	36	386.7 ± 11.358	31	332.8 ± 12.282
6 weeks old	45	346.5 ± 11.326	36	555.5 ± 12.998	35	528.6 ± 13.641	36	534.5 ± 13.593	30	460.0 ± 16.986
7 weeks old	45	449.2 ± 16.762	36	694.7 ± 13.703	34	657.7 ± 18.918	35	670.9 ± 15.353	27	567.2 ± 17.795
8 weeks old	40	560.0 ± 18.653	36	841.9 ± 16.198	33	831.7 ± 21.872	35	870.7 ± 17.853	27	747.6 ± 21.031
9 weeks old	40	700.8 ± 20.025	35	979.6 ± 17.056	32	991.3 ± 23.129	34	982.4 ± 17.974	26	844.3 ± 23.371
10 weeks old	40	807.0 ± 19.054	35	1099.4 ± 15.736	32	1100.5 ± 24.163	34	1092.7 ± 18.013	26	916.6 ± 24.394
11 weeks old	40	904.0 ± 20.749	35	1159.3 ± 15.987	32	1163.8 ± 24.699	34	1160.0 ± 17.350	26	1032.9 ± 21.840
12 weeks old	40	968.6 ± 20.578	35	1221.3 ± 15.100	32	1218.3 ± 24.932	34	1218.9 ± 17.510	26	1093.6 ± 19.480

TABLE 2

Mortality of the ducklings in the different lots

LOT. NO.	TREATMENT	TRIALS			AVERAGE
		1	2	3	
		per cent	*per cent*	*per cent*	*per cent*
I	Native method	21.16	6.29	66.67	31.37±12.096
II	Mash uncooked, with green feed	47.37	31.25	53.54	43.98± 4.461
III	Mash cooked, no green feed ..	42.11	37.50	63.34	47.67± 5.366
IV	Mash cooked, with green feed .	47.37	31.25	56.67	45.09± 4.977
V	Mash cooked, no green feed ..	52.64	62.50	63.34	59.39± 2.313

TABLE 3

Feed consumption and returns based upon 100 ducklings at the start

LOT NO.	TREATMENT	NO. OF DUCKLINGS WEANED	AVERAGE FEED PER BIRD	TOTAL FEED CONSUMED BY LOT	TOTAL COST OF FEED CONSUMED	AVERAGE WEIGHT PER BIRD	TOTAL WEIGHT OF WEANLINGS IN LOT	TOTAL VALUE OF WEANLINGS IN LOT	RETURNS ABOVE COST OF FEED
			kgm.	*kgm.*	*pesos*	*kgm.*	*kgm.*	*pesos*	*pesos*
I	Native method .	69	[a]	[b]	26.34	0.97	66.93	33.46	7.12
II	Mash uncooked, with green feed	56	5.78	323.68	22.50	1.22	68.32	34.16	11.66
III	Mash uncooked, no green feed .	52	6.08	316.16	21.97	1.22	63.44	31.72	9.75
IV	Mash cooked, with green feed	55	6.52	359.70	25.00	1.22	67.10	35.55	10.55
V	Mash cooked, no green feed .	40	6.93	277.20	19.26	1.09	43.60	21.80	2.54

[a] The feed consumed per bird in this lot consisted of 1.95 kgms. of "riced corn", 0.74 kgm. palay, 1.25 kgms. fresh shrimps, and 9.65 kgms. fresh snails.

[b] This lot consumed 134.55 kgms. of "riced corn", 51.06 kgms. palay, 86.25 kgms. fresh shrimps, and 665.85 kgms. fresh snails.

COLLEGE AND ALUMNI NOTES

Dr. Francisco M. Fronda left on the S. S. "Atsuta Maru" for Australia on April 8, 1940, to study the live stock industries in that country and to visit scientific centers with the aim of interesting them in the Seventh Pacific Science Congress to be held in Manila in 1942.

The following are the honor students for the second semester of the academic year, 1939-1940: José R. Velasco, Bonifacio R. Niones, Eleazar M. Galano, Teh Jin Siong, Florendo R. Naanep, Gregorio C. Fernandez, Chan Meesukh, Luciano C. Valencia, Gil F. Saguiguit, and Prayul Siddhijai.

Dr. Silverio M. Cendaña returned to the campus on April 19 from Mindanao, where he made a survey of insect pests of crop plants.

Dr. Andres F. Navarro, '12, Capt., P. A. Medical Corp Res. was Medical Inspector of the R.O.T.S. in Canlubang, Laguna, during the summer of 1940.

Doctor Navarro represents agriculture on the Board of Directors of the Masbate Chapter of the U. P. Alumni Association.

Several members of the College faculty read papers dealing with their respective lines before the 1940 Summer Institute held at the University of the Philippines, Manila, from April 10 to May 18. Dr. L. G. Gonzalez spoke on how more and better fruits may be produced in the Philippines; Dr. A. L. Teodoro, on how alcohol may be made to work as an efficient economical motor fuel in the Philippines; Dr. N. L. Galvez, on how we are to know that the soil is fertile; Dr. R. B. Espino, on ways by which yields of crop plants may be predicted; Dr. J. M. Capinpin, on modern fashions in crop improvement; Dr. V. Villegas, on pasture supplements for range cattle; Prof. A. B. Catambay, on the rôle of farm machinery in the improvement of Philippine farming; Dr. S. M. Cendaña, on how insect pests are fought with the aid of other insects.

Prof. J. E. Velmonte of the Department of Agricultural Economics returned to the campus on April 15 from a survey of economic conditions in Koronadal Valley and other places in Mindanao. Dr. N. B. Mendiola of the Department of Agronomy arrived on May 6 from Mindanao also, where he visited the U. P. land grant at Basilan to study ways of developing the property.

The opening exercises which ushered in the current academic year were held at Baker Memorial Hall on June 5. Dr. G. O. Ocfemia addressed the students in behalf of the faculty and Mr. Hipolito A. Custodia spoke on student life on the campus. Dean L. B. Uichanco welcomed the students.

The Reserve Officers' Service School of the Philippine Army held its Commencement Exercises at Baker Memorial Hall on Wednesday, May 29, 1940. Four hundred and seven officers were graduated. The Honorable Teofilo Sison, Secretary of National Defense, delivered the commencement address; and Major General Basilio Valdez, Chief of Staff, Philippine Army, distributed the diplomas. Some of the graduates are alumni of the College.

Several changes in the faculty of the college were made effective June 1.

Dr. Agustin Rodolfo of the College of Arts and Sciences in Baguio was transferred to the Department of Entomology as Assistant Professor to take charge of zoology.

The Board of Regents of the University of the Philippines approved the promotion of Dr. N. B. Mendiola from Professor and Head of the Department of Agronomy to Director of Research in the College of Agriculture. Dr. Leon G. Gonzalez was appointed Acting Head of the Department.

Dr. José M. Capinpin formerly Assistant Professor of Agronomy was made Assistant Professor of Agricultural Botany, *vice* Dr. José B. Juliano, resigned. Dr. Capinpin has also been designated Business Manager of *The Philippine Agriculturist.*

The designation of Mr. Gavino B. Rotor was changed from Assistant Instructor in Agronomy to Assistant Instructor in Agricultural Botany. Mr. José R. Velasco was appointed Assistant Instructor in Agricultural Botany effective April 5. Mr. Rotor and Mr. Velasco fill the positions left vacant by Mr. Feliciano Pantaleon and Mr. Roman Estioko, resigned.

Mr. Teodosio Buenaventura of the Department of Agricultural Education, Mr. Manuel Monsalud of the Department of Agricultural Chemistry, and Mr. Julio Sevilla of the Department of Agricultural Engineering were transferred to the College of Arts and Sciences in Baguio.

Dr. J. Konishi, entomologist of the Nanyo Kohatsu Kaisha Ltd., c/o Tokatu Bldg., Uchisaiwaicho, Kojimachi, Tokyo, Nippon, has been working on the College campus for over a month in an effort to secure living material, for introduction and establishment in the Japanese Mandated Islands of the Pacific, of parasitic wasps on white grubs which are a destructive pest there.

In the forty-second scientific conference of the National Research Council of the Philippines held on Friday, June 14, 1940, in the Auditorium of the Institute of Hygiene, University of the Philippines, Dr. G. O. Ocfemia discussed his report on "Plant pathology in the Sixth Pacific Science Congress and recent advances in plant pathology in the United States."

THE EXPERIMENT STATION

LIST OF AVAILABLE CIRCULARS

Circular No. 2.—Bud Rot of Coconut (Revised, June, 1934) *By G. O. Ocfemia*

Circular No. 3.—Experimental Errors and Application of the Probable Error to and the Interpretation of Experimental Results *By Nemesio B. Mendiola* (Published as Chapter IV in *A Manual of Plant Breeding for the Tropics*, 1926, also sold by THE PHILIPPINE AGRICULTURIST at ₱3.25, paper bound, and ₱5.25, cloth bound, in the Philippines, and ₱3.50 and ₱5.50 elsewhere, postpaid.)

Circular No. 5.—Poultry Raising Made Easy (Revised) *By F. M. Fronda*

Circular No. 7.—How to Produce New Varieties of Gumamela (Hibiscus) *By Nemesio B. Mendiola*

Circular No. 8.—Horse Breeding in the Philippines *By Valente Villegas*

Circular No. 9.—Fences for Farm Animals *By B. M. Gonzalez and J. P. Esguerra*

Circular No. 10.—Practical Directions for Coffee Planting *By Pedro A. David*

Circular No. 11.—The New College Copra Drier—Prepared in *Department of Agricultural Chemistry* with cooperation of *Department of Agronomy and Extension.* (Revised by *Moises M. Kalaw*).

Circular No. 14.—Beriberi: Its Causes and Prevention *By F. O. Santos*

Circular No. 15.—Cattle Raising under Philippine Conditions *By Valente Villegas*

Circular No. 16.—A Simple Farm Record for the Farmer *By Francisco M. Sacay*

Circular No. 17.—College Trapnest *By F. M. Fronda and P. S. Paje*

Circular No. 18.—Surveying for Area with a Surveyor's Staff *By Alexander Gordon*

Circular No. 19.—A Pageant: Illustrating the History and Growth of the College of Agriculture *By Anne F. Cole*

Circular No. 20.—Amount of Nutrients in Philippine Food Materials *By F. O. Santos and S. J. Ascalon*

Circular No. 21.—Cassava Growing and Cassava Starch Manufacture *By Nemesio B. Mendiola*

Circular No. 22.—Goat Raising *By Valente Villegas*

Circular No. 23.—Curing Pork and Making Sausage for Home Use *By Mariano Mondoñedo*

Circular No. 24.—Construction and Operation of Silos in the College of Agriculture *By José P. Esguerra*

Circular No. 26.—Training Cattle and Carabaos for Work *By Valente Villegas*

Circular No. 27.—Bunchy-top of Abacá *By G. O. Ocfemia*

Circular No. 28.—Cotton Culture *By Eulalio P. Baltazar*

Circular No. 29.—Collegiate Education in Agriculture *By L. B. Uichanco*

Circular No. 30.—What Should Filipino Ornamental Gardens and Ornamental Plants Be? *By N. B. Mendiola*

Circular No. 31.—How to Slaughter and Dress Farm Animals *By Valente Villegas and M. Mondoñedo*

The Circulars Nos. 1, 3, 4, 6, 12, 13, and 25 are out of print.

The price of the Circulars listed above is 10 centavos each except Nos. 5, 10, 16, 21, and 30 the price of which is 20 centavos.

ALL ORDERS SHOULD BE ADDRESSED TO THE
BUSINESS MANAGER, THE PHILIPPINE AGRICULTURIST,
AGRICULTURAL COLLEGE, LAGUNA, PHILIPPINES

The Philippine Agriculturist

(Formerly The Philippine Agriculturist and Forester)

Published by the COLLEGE OF AGRICULTURE
UNIVERSITY OF THE PHILIPPINES

Vol. I—2
Vol. II—4-6
Vol. III—9-10
Vol. IV—3, 5-6, 7
Vol. V—2, 3, 5, 6, 7, 8, 9, 10
Vol. VI—complete
Vol. VII—complete
Vol. VIII—3, 4, 5, 6, 7, 8-9, 10
Vol. IX—3, 4-5, 8-9
Vol. XI—3, 4, 5, 6, 7, 8
Vol. XII—10
Vol. XIII—1, 3, 4, 5, 6, 8, 9, 10
Vol. XIV—complete
Vol. XV—complete
Vol. XVI—3, 5, 6, 7, 8, 9, 10
Vol. XVII—6, 7, 8, 9, 10
Vol. XVIII—complete
Vol. XIX—complete
Vol. XX—complete
Vol. XXI—complete
Vol. XXII—complete
Vol. XXIII—complete
Vol. XXIV—complete
Vol. XXV—complete
Vol. XXVI—complete
Vol. XXVII—complete
Separate indices to Vol. I to XXVII
Consolidated index to Vol. I to XX

Back copies sell at 40 centavos. Indices 10 centavos each.

Consolidated index 50 centavos excluding postage

Send your order to the BUSINESS MANAGER, THE PHILIPPINE AGRICULTURIST, AGRICULTURAL COLLEGE, LAGUNA, PHILIPPINES.

A Handbook of Philippine Agriculture

A new book on practical agriculture issued in commemoration of the Thirtieth Anniversary of the College of Agriculture. Contains useful information on different branches of agriculture. Of great practical value to farmers, farm managers, agricultural teachers, students, extension workers, and researchers.

Cloth 803 pages 4½" X 6¾"

Price postpaid:

Philippines	₱2.30
United States and foreign countries	2.60

Send your order to THE PHILIPPINE AGRICULTURIST, AGRICULTURAL COLLEGE, LAGUNA, PHILIPPINES